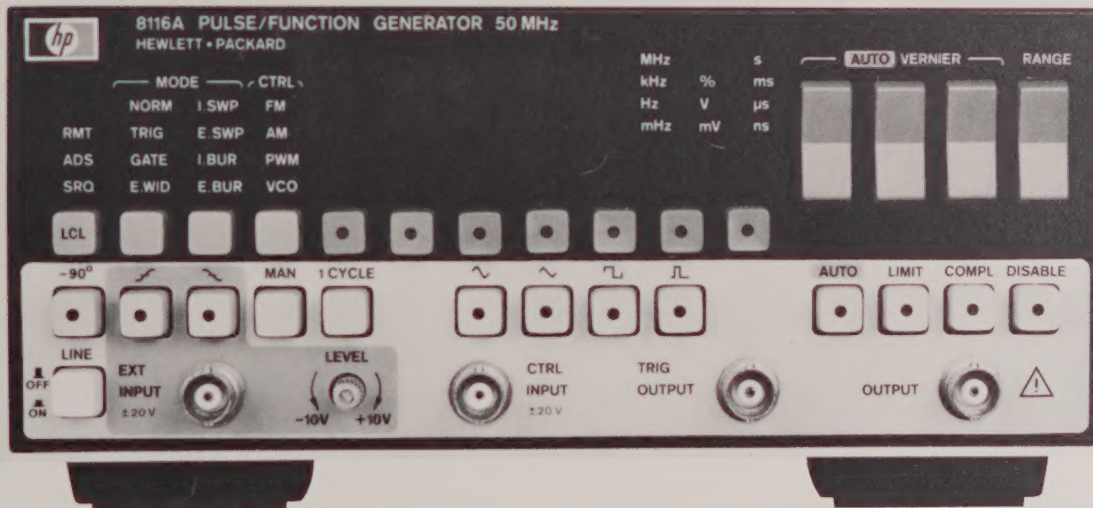


OPERATING AND SERVICE MANUAL

8116A

PROGRAMMABLE PULSE/FUNCTION GENERATOR 50 MHz



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MANUAL CHANGES

MANUAL IDENTIFICATION

Model Number: 8116A
Date Printed: JUNE 1984
Part Number: 08116-90002

This supplement contains important information for correcting manual errors and for adapting the manual to instruments containing improvements made after the printing of the manual.

To use this supplement:

Make all ERRATA corrections.

Make all appropriate serial number related changes indicated in the tables.

Serial Prefix or Number	Make Manual Changes	Serial Prefix or Number	Make Manual Changes
2334A00325	1		
2516A	1,2		

► NEW ITEM

ERRATA

Page 6-6. Table 6-3. Replaceable Parts.

Add: A1C409, HP Part Number 0160-3875, C-FXD 22PF 5% 200V.

Page 6-7. Table 6-3. Replaceable Parts.

Add: A1CR401, HP Part Number 1901-0518, DIODE SCHOTTKY.

Add: A1CR402, HP Part Number 1901-0518, DIODE SCHOTTKY.

NOTE

Manual change supplements are revised as often as necessary to keep manuals as current and accurate as possible. Hewlett-Packard recommends that you periodically request the latest edition of this supplement. Free copies are available from all HP offices. When requesting copies quote the manual identification information from your supplement, or the model number and print date from the title page of the manual.

Page 6-7. Table 6-3. Replaceable Parts.

Change: A1Q210 to HP Part Number 1854-0215, XSTR SI 2N3904.

Add: A1Q216, HP Part Number 1853-0036, XSTR SI 2N3906.

Page 6-8. Table 6-3. Replaceable Parts.

Change: A1R9 to HP Part Number 0757-0476, RF 301K 1%.

Change: A1R202 to HP Part Number 0757-0419, RF 681 1%.

Change: A1R215 to HP Part Number 0757-0419, RF 681 1%.

Add: "" to A1R219 and A1R222.

Add: A1R219*, HP Part Number 0757-0442, RF 10K 1%.

Add: A1R222*, HP Part Number 0757-0442, RF 10K 1%.

Add: A1R278, HP Part Number 0757-0401, RF 100 1%.

Page 6-9. Table 6-3. Replaceable Parts.

Add: A1R273, HP Part Number 0757-0280, RF 1K 1%.

Add: A1R274, HP Part Number 0757-0407, RF 200 1%.

Add: A1R275, HP Part Number 0698-4416, RF 169 1%.

Add: A1R276, HP Part Number 0757-0419, RF 681 1%.

Add: A1R277, HP Part Number 0757-0419, RF 681 1%.

Add: A1R454, HP Part Number 0757-0276, RF 61.9 1%.

Page 6-12. Table 6-3. Replaceable Parts.

Add: A3R21, HP Part Number 0698-3162, RF 46.6K 1%.

Change: A3U10 to HP Part Number 1818-1768.

Delete: A3U11.

Change: A3U38 to HP Part Number 1820-1197.

Page 8-9. Schematic 3.

Change: Schematic 3 as shown in Figures 1 and 2.

Page 8-16. Schematic 6.

Change: Schematic 6 as shown in Figures 3 and 4.

Page 8-18. Schematic 7.

Change: Schematic 7 as shown in Figure 5.

CHANGE 1

Page 6-8. Table 6-3. Replaceable Parts.

Change: A1R220 to HP Part Number 0698-3152, RF 3.48K 1%.

Change: A1R223 to HP Part Number 0698-3152, RF 3.48K 1%.

Page 6-9. Table 6-3. Replaceable Parts.

Change: A1R406 to HP Part Number 0757-0421, RF 825 1%.

Change: A1R408 to HP Part Number 0698-4447, RF 280 1%.

Page 6-12. Table 6-3. Replaceable Parts.

Change: A3R16 to HP Part Number 1810-0280, R-NETWORK 9X10K.

Page 6-15. Table 6-3. Replaceable Parts.

Change: A2R30 to HP Part Number 0698-3152, RF 3.48K 1%.

Change: A2R33 to HP Part Number 0757-0458, RF 51.1K 1%.

Change: A2R43 to HP Part Number 2100-3252, R-VAR 5K 10%.

Page 8-16. Schematic 6.

Change: Value of A1R220 and A1R223 to 3.48K.

Page 8-18. Schematic 7.

Change: Value of A1R406 to 1300.

Change: Value of A1R408 to 280.

CHANGE 2

Page 6-5. Table 6-3. Replaceable parts.

Change: MP4 to HP Part Number 08116-00204.

Change: MP7 to HP Part Number 5021-5813.

Change: MP8 to HP Part Number 5021-0512.

Change: MP17 to HP Part Number 5001-1227.

Change: MP18 to HP Part Number 08116-04102.

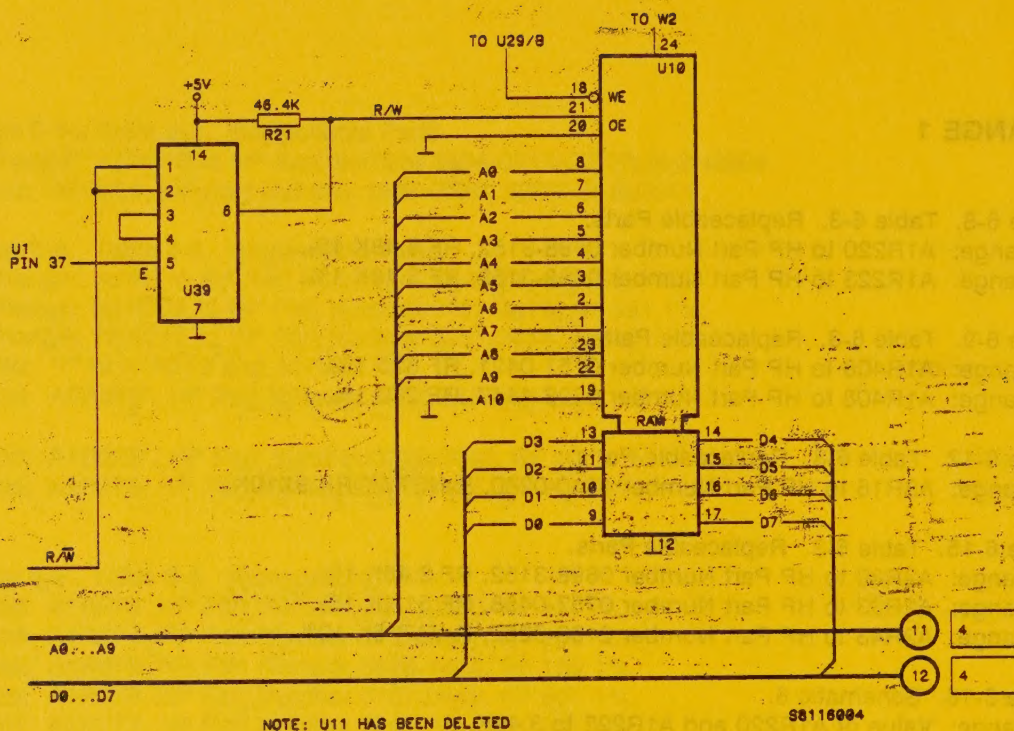


FIGURE 1

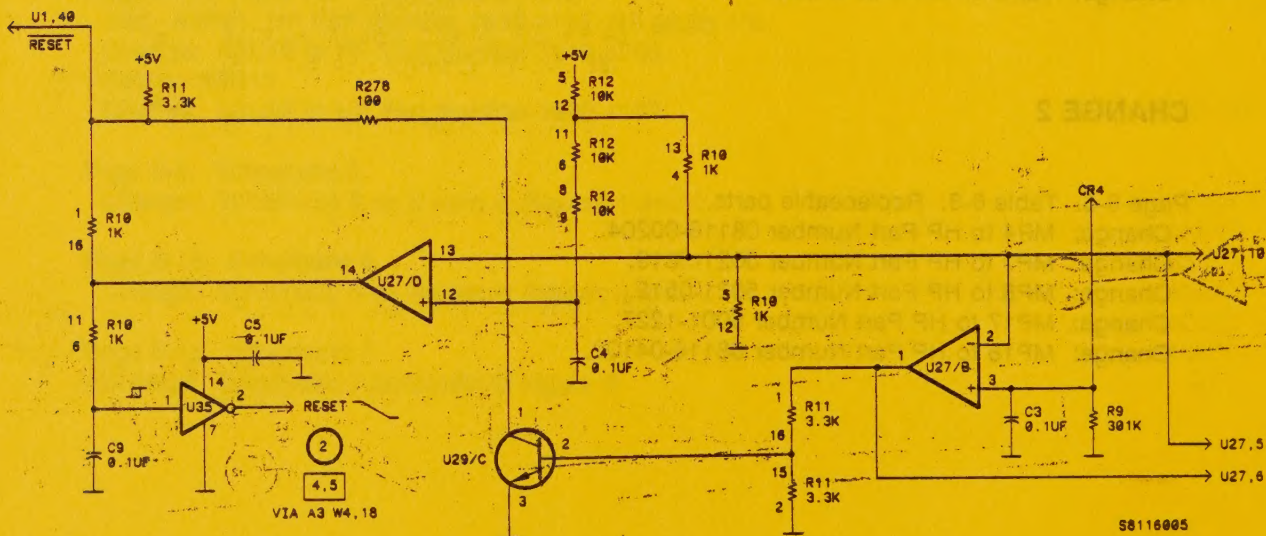


FIGURE 2



38. 24

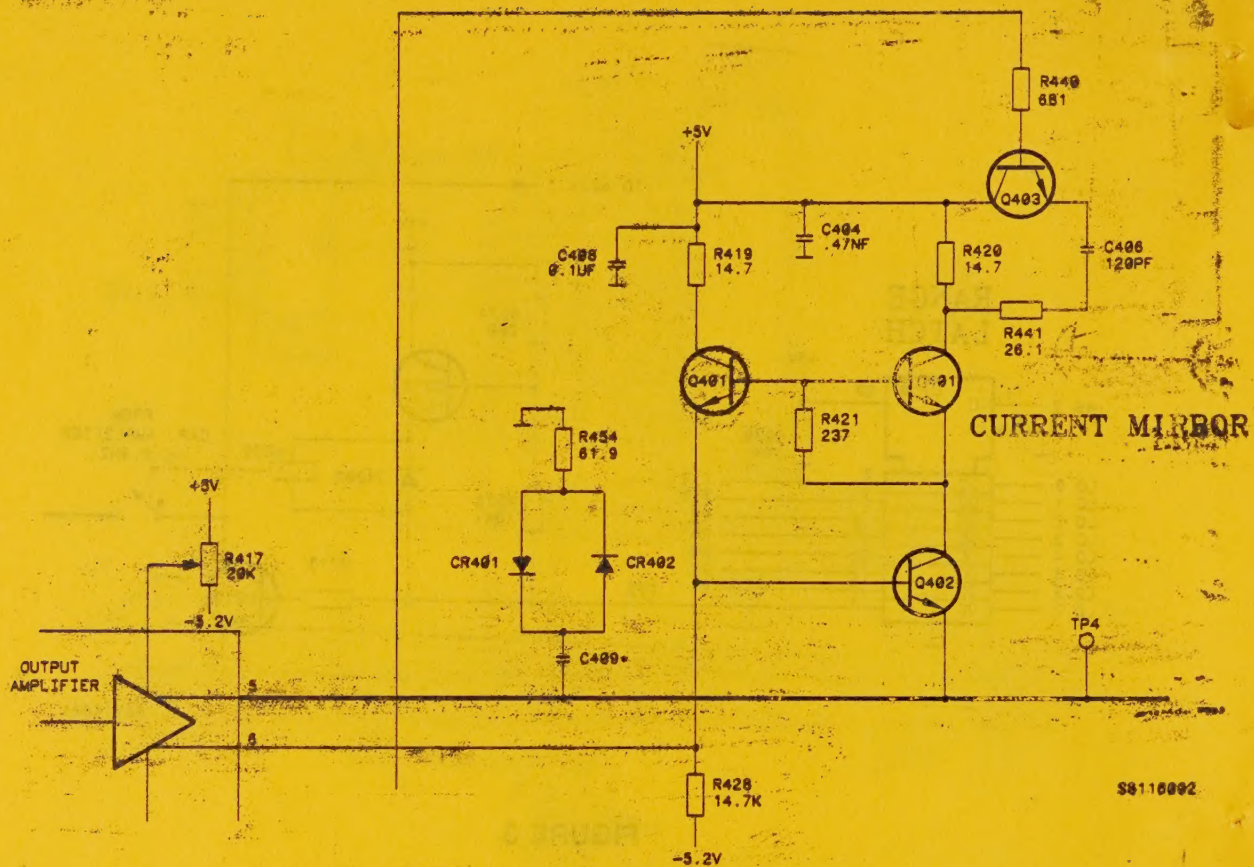
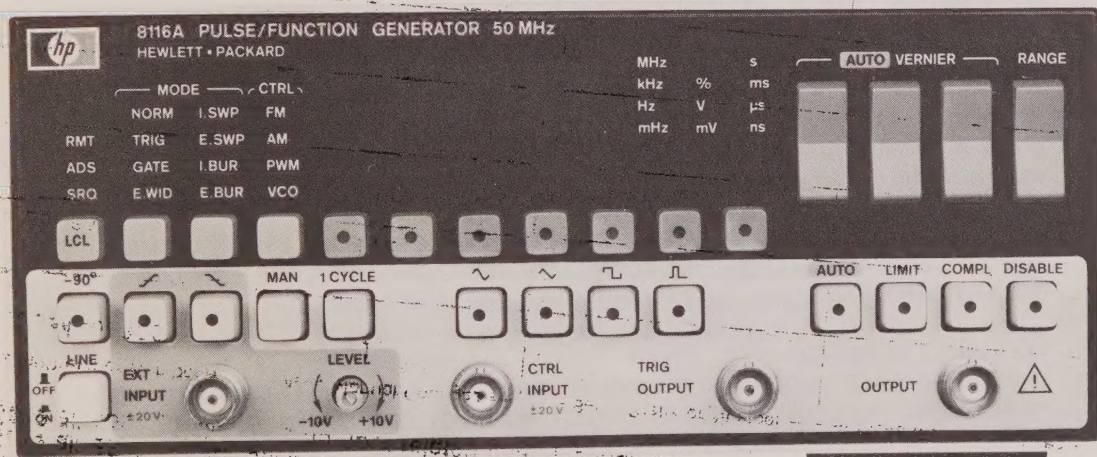


FIGURE 5

OPERATING AND SERVICE MANUAL

8116A PROGRAMMABLE PULSE/FUNCTION GENERATOR 50 MHz



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CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY

This Hewlett-Packard product is warranted against defects in material and workmanship for a period of one year from date of shipment. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

HP warrants that its software and firmware designated by HP for use with an instrument will execute its programming instructions when properly installed on that instrument. HP does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

For products returned to HP for warranty service, Buyer shall prepay shipping charges to HP and HP shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to HP from another country.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HP SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

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THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HP SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

ASSISTANCE

Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

OPERATING AND SERVICE MANUAL

8116A PROGRAMMABLE PULSE/FUNCTION GENERATOR 50 MHz

(Including Option 001)

SERIAL NUMBERS

This manual applies directly to instrument with serial number **2334G02896** and higher. Any changes made in instruments having serial numbers higher than the above number will be found in a "Manual Changes" supplement supplied with this manual. Be sure to examine this supplement for any changes which apply to your instrument and record these changes in the manual. Backdating information for instruments with lower serial numbers can be found in Section 7 (yellow pages).

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FEDERAL REPUBLIC OF GERMANY

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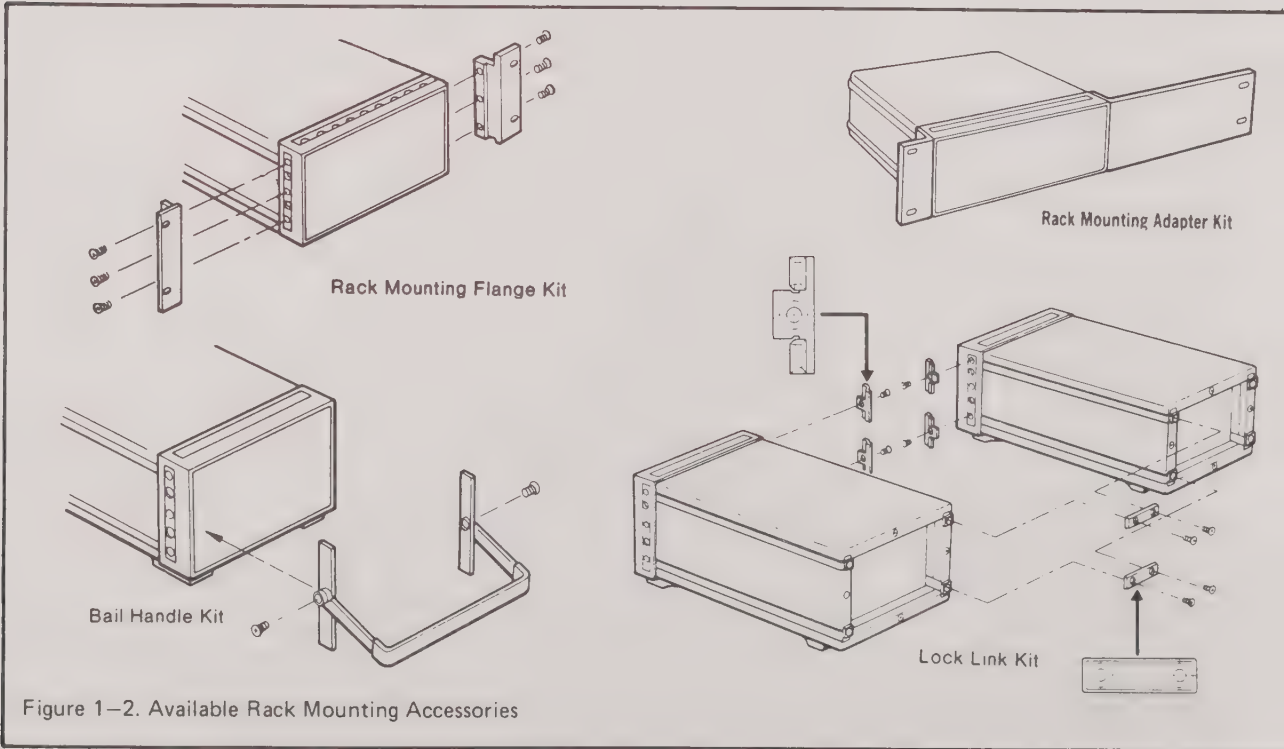
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SECTION I GENERAL INFORMATION

1-1 INTRODUCTION

1-2 This Operating and Service Manual contains information required to install, operate, test, adjust and service the Hewlett-Packard Model 8116A. Figure 1-1 shows the mainframe and accessories supplied. This section covers instrument identification, description, accessories, specifications, and other basic information.

1-3 A Microfiche version of this manual is available on 4 x 6 inch microfilm transparencies (order number on title page). Each microfilm contains up to 60 photoduplicates of the manual pages. The microfiche package also includes the latest Manual Changes supplement as well as all pertinent Service Notes.

1-4 SPECIFICATIONS

1-5 Instrument specifications are listed in Table 1-2. These specifications are the performance standards or limits against which the instrument is tested.

1-6 SAFETY CONSIDERATIONS

1-7 The 8116A is a Safety Class 1 instrument (it has an exposed metal chassis that is directly connected to earth via the power supply cable). Before operation, the instrument and manual, including the red safety page, should be reviewed for safety markings and instructions. These must then be followed to ensure safe operation and to maintain the instrument in a safe condition.

1-8 INSTRUMENTS COVERED BY MANUAL

1-9 Attached to the rear of this instrument is a serial number plate (Figure 1-3). The first four digits of the serial number only change when there is a significant change to the instrument. The last five digits are assigned to instruments sequentially. The contents of this manual apply directly to the instrument serial number quoted on the title page. For instruments with lower serial numbers, refer to the backdating information in Section VII of this manual. For instruments with higher serial numbers, refer to the Manual Change sheets at the end of this manual. In addition to change information, the Manual Change sheets may contain information for correct-

ing errors in the manual. To keep this manual as up-to-date and accurate as possible, Hewlett-Packard recommends that you periodically request the latest Manual Change supplement. The supplement for this manual is identified with the manual's print date and part number, both of which appear on this manual's title page. Complimentary copies of the supplement are available from Hewlett-Packard.



Figure 1-3. Serial Number Plate

1-10 DESCRIPTION

1-11 The HP 8116A Programmable Pulse/Function Generator operates over the frequency range 1 mHz to 50 MHz and up to 32 V peak-to-peak amplitude. Capabilities include:

- Multiwaveform generation (sine, square, triangle, pulse)
- 6 ns transition time for pulse and square-wave
- Variable pulse width down to 10 ns
- AM/FM/PWM modulation modes
- VCO control mode
- Fully HP-IB programmable
- Internal and external logarithmic sweep (Opt. 001)
- Internal and external burst mode for all waveforms (Opt. 001)

1-12 A unique self-prompting operating concept, plus the full HP-IB programmability, provide an easy means to execute single manual operation or complex automatic tasks.

1-13 8116A Options.

1-14 Option 001. The 8116A can provide increased capabilities with the addition of Option 001. Added capabilities include:

- Logarithmic sweep (selectable internal or external triggering)
- Counted burst (selectable internal or external triggering)
- Hold input for sine, triangle and squarewave.

1-15 ACCESSORIES SUPPLIED

1-16 The 8116A is supplied complete with the following items:

ITEM	HP PART NUMBER
750 mA fuse for 220/240 V operation or, 1.5 A fuse for 100/120 V operation	2110-0063 2110-0043
Power cable	See Figure 2-2

1-17 ACCESSORIES AVAILABLE

ITEM	HP PART NUMBER
Carrying handle - Bail Handle Kit	5061-2001
Rack mounting adaptors: Rack mounting flange and filler panel for rack mounting a single 8116A,	5061-0072
Rack mounting flange and lock link kit	5061-0074 5061-0094
for rack mounting two 8116A's	

1-18 RECOMMENDED TEST EQUIPMENT

1-19 Equipment required to maintain the 8116A is listed in Table 1-1. Alternative equipment can be substituted provided that it meets or exceeds the critical specifications listed in the table.

Table 1-1. Recommended Test Equipment

Instrument	Recommended Model	Required characteristics	Adequate Substitute	Use*
Counter	HP 5335A	50 MHz, Start/Stop, T I, A to B	HP 5345A + HP 5363B	P, A P, A
DVM	HP 3455A	DC .1 V-10 V, .004 % acc.	HP 3456A	P, A
DMM	HP 3465A	AC .1 V-10 V DC .1mA - 10mA	HP 3466A	P, A, T
Function Generator	HP 3325A	20 MHz, THD < .1 %		P, A
Real Time Scope	HP 1740A	100 MHz Bandwidth	HP 1743A	P, A, T
Sampling Scope	TEK 7603 with 7T11/7S11 and S-3A	1 GHz	HP 140A/ 1410A	P, A
Spectrum Analyzer	HP 3580A	5 Hz - 50 kHz	HP 3585A	P, A
Spectrum Analyzer	HP 181T/ 8557A	350 MHz		P
Signature Analyzer	HP 5005A		HP 5004A	T
Logic Probe	HP 545A	TTL		T

* P = Performance Test; A = Adjustments; T = Troubleshooting

Table 1–2. Specifications

The following specifications apply with 50 Ohm load resistance. Output levels double when driving into high impedance (up to 32 Vpp).

Accuracy specifications apply from 15°C to 35°C.

For temperatures below 15°C and above 35°C see

“General” information.

WAVEFORMS

Sine, Triangle, Ramp, Square, Pulse, Haversine,
Havertriangle, DC

TIMING CHARACTERISTICS

Frequency

Range: 1.00 mHz to 50.0 MHz

Resolution: 3 digits

Accuracy (% of setting)	Pulse mode or 50 % duty cycle	≠ 50 % duty cycle
1.0 mHz to 99.9 kHz	± 3 % ± 0.3 mHz	± 3 % ± 0.6 mHz
100 kHz to 9.99 MHz	± 5 %	± 10 %
10.0 MHz to 50 MHz	± 5 %	-----

Repeatability: Factor 4 better than accuracy

Jitter: < 0.1 % + 100 ps (50 % duty cycle and pulse
mode)

< 0.2 % + 100 ps (= 50 % duty cycle)

Stability: ± 0.2 % (1 hour)
± 0.5 % (24 hours)

Duty Cycle (sine, triangle, square)

Range: 10 % to 90 % (1 mHz to 999 kHz)
20 % to 80 % (1 MHz to 9.99 MHz)

Resolution: 1 %

Accuracy: ± 0.5 digits (100 mHz to 999 kHz)
± 3.0 digits (1 MHz to 9.99 MHz)

Pulse Width (pulse mode)

Range: 10.0 ns to 999 ms

Resolution: 3 digits

Accuracy: ± 5 % of setting ± 2 ns

Repeatability: Factor 4 better than accuracy

Jitter: 0.2 % + 200 ps (width ≤ 10 μs)
0.1 % (width > 10 μs)

Max. Width: Period –10 ns

OUTPUT CHARACTERISTICS

Output Impedance: 50 Ohm ± 5 %

Reflection: < 12 % (ampl. ≥ 100 mVpp)

Amplitude/Offset

Amplitude and offset are independently variable within
the following two level windows

Level window	± 800 mV	± 8.00 V
Amplitude range	10.0 mVpp to 99.9 mVpp	100 mVpp to 16.0 Vpp
Ampl. resolution	3 digits	3 digits
Ampl. accuracy*	± 5 % [0.45 dB]	± 5 % [0.45 dB]
Repeatability	Factor 4 better than accuracy	
Offset range	0 to ± 795 mV	0 to ± 7.95 V
Offset resolution	3 digits (best case 100 μV)	3 digits (best case 1 mV)
Offset accuracy	± 1 % of setting ± 1 % of amplitude ± 4 mV	± 0.5 % of setting ± 1 % of amplitude ± 40 mV
Repeatability	Factor 4 better than accuracy	

* The amplitude accuracy for sine and triangle is
specified at 1 kHz. For other frequencies see the following
flatness specifications.

Amplitude Flatness (50 % duty cycle)	Sine	Triangle
1.00 mHz to 999 kHz	± 3 % (0.26 dB)	± 3 %
1.00 MHz to 9.99 MHz	± 5 % (0.45 dB) + 5 % (0.45 dB)	± 5 % + 5 %
10.0 MHz to 50.0 MHz	– 15 % (1.41 dB)	– 25 %

DC Voltage (all waveform selection keys deactivated)

Range: 0 to ± 7.95 V

Resolution: 3 digits (best case 1 mV)

Accuracy: ± 0.5 % of setting ± 20 mV

WAVEFORM CHARACTERISTICS

Sine (Normal Mode, 50 % duty cycle)

Total Harmonic Distortion (THD): < 1 % (–40 dB),
(10 Hz to 50 kHz)

Harmonic Signals: More than 34 dB below fundamental
(50 kHz to 1 MHz)
More than 23 dB below fundamental
(1 MHz to 50 MHz, > 20 mVpp
–8 Vpp)

THD may increase by 3 dB below 10°C

Triangle, Ramp

Non-linearity: < ± 3 % (10 % to 90 % of amplitude,
100 mHz to 1 MHz)

Square, Pulse

Rise/Fall time: < 6 ns (10 % to 90 % of amplitude)

Pulse Perturbations: < ± 5 % of amplitude ± 2 mV

OPERATING MODES

Norm: Continuous waveform is generated

Trig*: Each input cycle generates a single output cycle

Gate*: External signal enables oscillator. First output cycle synchronous with active trigger slope.
Last cycle always completed.

External Width : External signal will be shaped to (pulse mode only) determine output pulse width and period. Amplitude and offset controls are active.

Sweep: Logarithmic sweep for all waveforms
(Opt. 001 only) up to full range (1 MHz to 50 MHz) between selected start and stop frequency. Sweep time per decade selectable in 1-2-5 sequence between 10 ms and 500 s.
Int. Sweep: Continuous sweep cycles.
Ext. Sweep: One sweep cycle generated on receipt of external signal.
(Duty Cycle 50 %)

Burst*: Preprogrammed number of periods
(Opt. 001 only) (1 to 999) is generated. Minimum time between bursts is 100 ns. For bursts with only one period, min time between bursts is 0 ns.
Int. Burst: (pulse mode not available)
Internally generated signal starts burst.
Repetition time: 20 ns to 999 ms
Ext. Burst: (all waveforms)
External signals starts burst.
Freq max = 40 MHz

* Startphase of sine and triangle switchselectable to 0° and -90° for haversine and havertriangle.

AUXILIARY OPERATING MODES

Man: Simulates external input.

1 Cycle: Provides a single output period in I. BURST
(Opt. 001 only) and E. BURST mode.

Auto: In NORM mode, all parameters can be automatically incremented or decremented with selectable resolution. Pushing the AUTO button activates the AUTO vernier, which then can be started with the selected vernier key. AUTO vernier stop is accomplished by an external trigger input or pushing AUTO.

Limit: Maximum high and low levels into 50 Ohm can be limited to protect the device under test. Pushing the limit key will set the limits to the actual levels, which then cannot be exceeded as long as the mode is active.

Compl: Switchselectable normal/complement output.

Disable: Relay disconnects all output circuitry.

CONTROL MODES (external voltage modulates output signal)

FM (frequency modulation)

Deviation: $\pm 5\%$ max

Sensitivity: 1 V for 1 % deviation

Modulation bandwidth: dc to 20 KHz (carrier freq. < 10MHz)
dc to 3kHz (carrier freq. > 10MHz)

AM (amplitude modulation)

Sensitivity: ± 2.5 V for 100 % modulation depth
+ 2.5 V, -7.5 V for DSBSC

Modulation bandwidth: dc to 1 MHz

Envelope distortion: < 1 % for modulation depth less than 90 % (dc to 50 kHz) NOT COMPL

PWM (pulse width modulation)

Pulse width ratio: 10:1 max

Sensitivity: ± 6.5 V typical for ratio 10:1.

Pulse width ranges: 10 ns to 1 s in eight nonoverlapping decade ranges

VCO (voltage controlled oscillator)

External voltage linearly sweeps 2 full frequency decades.

Modulation range: 1:100 with 0.1 V to 10 V

Modulation bandwidth: dc to 1 kHz

SUPPLEMENTARY PERFORMANCE CHARACTERISTICS

(Supplementary characteristics are intended to provide information useful in applying the instrument by giving non-warranted typical performance parameters).

AUXILIARY INPUTS AND OUTPUTS

Ext. Input: Threshold level: ± 10 V adjustable

Max input voltage: ± 20 V

Sensitivity: 500 mVpp

Min pulse width: 10 ns

Input impedance: 10 kOhm

Trigger slope: pos./neg. and trigger off

Control Input Max input voltage: ± 20 V

Input impedance: 10 kOhm

Trigger Output Output levels: 0/2.4 V into 50 Ohm
0/4.8 V into open
Output impedance: 50 Ohm

X-Output (Opt. 001 only): Increasing X-Output voltage with increasing sweep frequency. 0 V corresponds to start frequency and slope is 1.5 V/frequency decade. The max. output voltage is 10 V.

Marker Output (Opt. 001 only): TTL compatible voltage with positive transition at selected marker frequency.

Hold Input (Opt. 001 only): Main output will hold at the instantaneous voltage level when input signal becomes TTL high. Applicable for sine, triangle and square below 10 Hz.

Droop: 0.01 % of amplitude/s

Max input voltage: ± 20 V

HP-IB CAPABILITY

All modes and parameters can be programmed. The external input threshold level is not programmable.

Programming Times

Listen (time for 8116A to receive and verify message)

Data transmission time: 130 μ s per ASCII character.

Modes: 11 ms

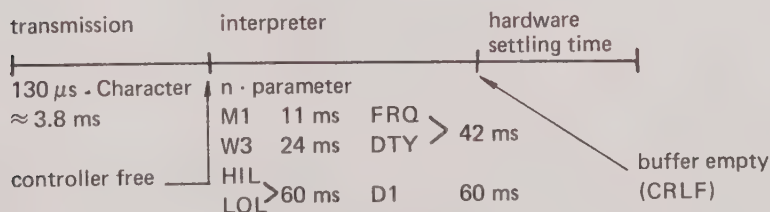
Waveforms:  24 ms
330 ms

DTY	60 ms	in one string
FRQ	60 ms	
WID	24 ms	42 ms
HIL	110 ms	60 ms
LOL	100 ms	
AMP	150 ms	90 ms
OFS	150 ms	

ENABLE, DISABLE, 60 ms
LIMIT, NORM/COMPL

EXAMPLE:

"M1 W3 FRQ 1 KHz DTY 20 % HIL 3 V LOL 1 V D1"



Talk (time for 8116A to transmit a message)

Learn Mode, Error recognition: 1 ms/character.

Status: < 15 ms.

Settling Times (time to execute message)

Frequency, Duty Cycle, Width, Amplitude: 5 ms

Offset, DC Voltage: 30 ms

GENERAL

Warm-up Time: 15 min to meet all specifications

Environmental:

Storage temperature: -40°C to 70°C

Operating temperature: 0°C to 55°C

Accuracy Specifications apply from 15°C to 35°C .

Accuracy derating factor for temperatures outside this range: $1 + 0.05 \times \Delta^{\circ}\text{C}$.

$\Delta^{\circ}\text{C}$ is the temperature deviation below 15°C and above 35°C .

Humidity Range: 95 % R.H., 0°C to 40°C .

Power-off storage: After eight hours of operation, battery maintains all current mode and parameter information up to half a year with instrument switched off.

Power: 100/120/220/240 V rms $\pm 5\%$, -10% ;
48–440 Hz, 120 VA max.

Weight: Net 5.9 kg (13 lbs), Shipping 8.0 kg (18 lbs).

Dimensions: 89 mm high, 213 mm wide, 450 mm deep
(3.5 x 8.4 x 17.7 in)

Options:

001 Burst, Sweep and Hold

910 Additional Operating and Service Manual
(Part No.: 08116-90001).

SECTION II INSTALLATION

2-1 INTRODUCTION

2-2 This section provides installation instructions for the instrument and its accessories. It also includes information about initial inspection and damage claims, preparation for use, and packaging, storage and shipment.

2-3 INITIAL INSPECTION

2-4 Inspect the shipping container for damage. If the container or cushioning material is damaged, it should be kept until the contents of the shipment have been checked for completeness and the instrument has been checked mechanically and electrically. The contents of the shipment should be as shown in Figure 1-1 plus any accessories that were ordered with the instrument. Procedures for checking the electrical operation are given in Section 4. If the contents are incomplete, if there is a mechanical damage or defect, or if the instrument does not pass the operator's checks, notify the nearest Hewlett-Packard office. Keep the shipping materials for carrier's inspection. The HP office will arrange for repair or replacement without waiting for settlement.

2-5 PREPARATION FOR USE

WARNING

To avoid hazardous electrical shock, do not perform electrical tests when there are signs of shipping damage to any portion of the outer enclosure (covers, panels, meters).

2-6 Power Requirements

2-7 The instrument requires a power source of 100/120/220 or 240 Vrms (+5% - 10%) at a frequency of 48-440 Hz single phase. The maximum power consumption is 120 VA.

2-8 Line Voltage Selection

CAUTION

BEFORE SWITCHING ON THIS INSTRUMENT make sure that the instrument is set to the local line voltage. The line voltage selector switches can be seen through the lefthand side of the instrument cover to the rear. The correct setting for the country of destination will have been made at the factory. The instrument power fuse is located on the rear panel. To access the line selector switches, first DISCONNECT the power cord, then remove instrument top cover by releasing the captive securing screw at rear and sliding cover off.

CAUTION

Do not change the LINE SELECTOR switch settings with the instrument on or with power connected to the rear panel.

2-9 Figure 2-1 provides information for line voltage and fuse selection:

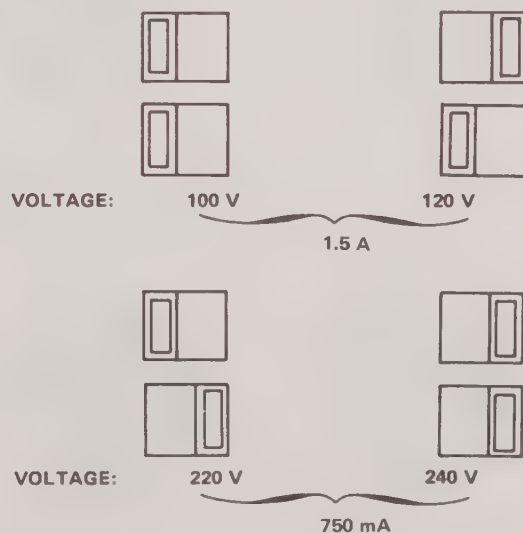


Figure 2-1. Sliding Switches Positions for different Line Voltages

2-10 Power Cable

WARNING

To avoid the possibility of injury or death, the following precautions must be followed before the instrument is switched on:

- If this instrument is to be energized via an autotransformer for voltage reduction, make sure that the common terminal is connected to the grounded pole of the power source.
- The power cable plug shall only be inserted into a socket outlet provided with a protective ground contact. The protective action must not be negated by the use of an extension cord without a protective conductor.
- Before switching on the instrument, the protective ground terminal of the instrument must be connected to a protective conductor of the power cable. This is verified by checking that the resistance between the instrument chassis and the front panel and the ground pin of the power cable plug is zero ohms.

2-11 In accordance with international safety standards, this instrument is equipped with a three-wire power cable. When connected to an appropriate ac power receptacle, this cable grounds the instrument cabinet. The type of power cable shipped with each instrument depends on the country of destination. Refer to Figure 2-2 for the part number of the power cords available.

2-12 The following work should be carried out by a qualified electrician and all local electrical codes must be observed. If the plug on the cable supplied does not fit your power outlet, or if the cable is to be attached to a terminal block, then cut the cable at the plug end and re-wire it. The colour coding used in the cable will depend on the cable supplied (see Figure 2-2). If a new plug is to be connected, the plug should meet local safety requirements and include the following features:

adequate load-carrying capacity (see table of specifications in Section 1)

ground connection

cable clamp

2-13 HP-IB Connector

2-14 The rear panel HP-IB connector (Figure 2-3) is compatible with the connectors on Cable Assemblies 10833A, B, C and D. If a cable is to be locally-manufactured, use connector male, HP part number 1251-0293.

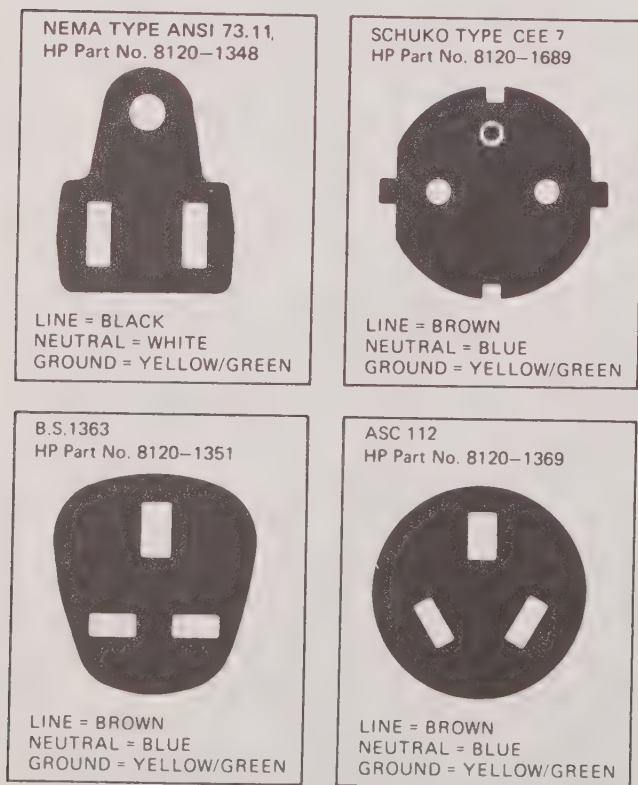


Figure 2-2. Power Cables Available: Plug Identification

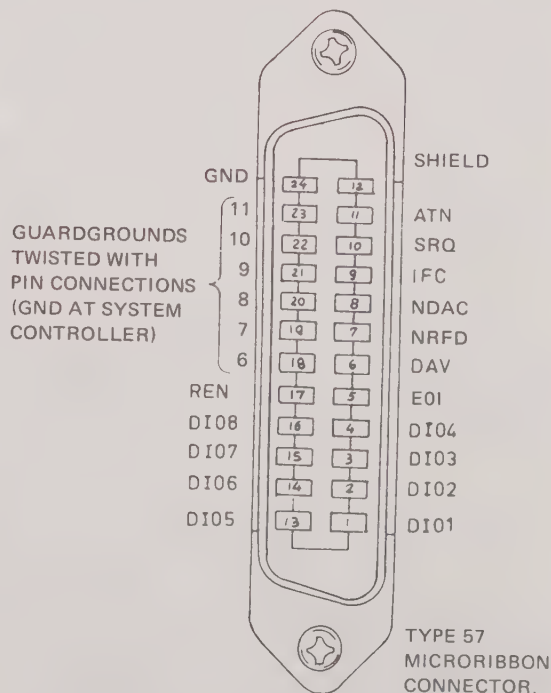


Figure 2-3. HP-IB Connector

2–15 HP-IB Logic Levels

2–16 The 8116A HP-IB lines use standard TTL logic. Logic levels are as follows:

True = low = digital ground or 0V dc to +0.4V dc,
False = high = open or +2.5V dc to +5V dc.

All HP-IB lines have LOW assertion ("1") states. High states are held at +3V dc by pullups within the instrument. When a line functions as an input, approximately 3.2mA of current is required to pull it low through a closure to digital ground. When a line functions as an output, it will sink up to 48mA in the low state and approximately 0.6mA in the high state.

CAUTION

Isolation. The HP-IB line screens are not isolated from outer chassis (frame) ground.

2–17 Operating Environment

The operating temperature limits are 0°C to 55°C. The specifications also apply over this temperature range.

2–18 CLAIMS AND REPACKAGING

2–19 Claims for Damage

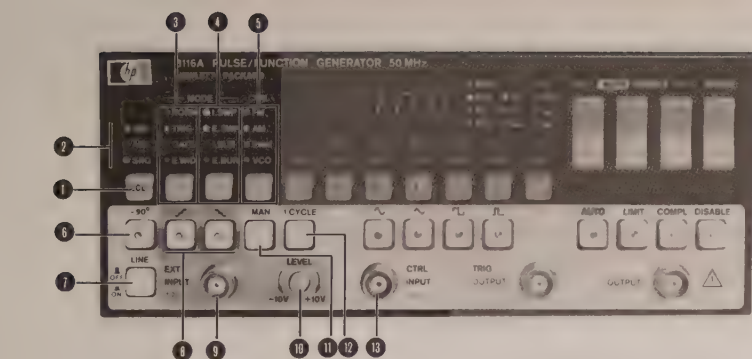
2–20 If physical damage is evident or if the instrument does not meet specification when received, notify the carrier and the nearest Hewlett-Packard Sales/Service Office. The Sales/Service Office will arrange for repair or replacement of the unit without waiting for settlement of the claim against the carrier.

2–21 Storage and Shipment

2–22 The instrument can be stored or shipped at temperatures between –40°C and 75°C. The instrument should be protected from temperature extremes which cause condensation within it.

2–23 If the instrument is to be shipped to a Hewlett-Packard Sales/Service Office, attach a tag showing owner, return address, model number and full serial number and the type of service required. The original shipping carton and packaging material may be re-usable but the Hewlett-Packard Sales/Service office will also provide information and recommendations on materials to be used if the original packing is not available or re-usable. General instructions for re-packing are as follows:

1. Wrap instrument in heavy paper or plastic.
2. Use strong shipping container. A double wall carton made of 350-pound test material is adequate.
3. Use enough shock-absorbing material (3 to 4-inch layer) around all sides of instrument to provide firm cushion and prevent movement inside container. Protect control panel with cardboard.
4. Seal shipping container securely.
5. Mark shipping container FRAGILE to encourage careful handling.
6. In any correspondence, refer to instrument by model number and serial number.



OPERATING AND CONTROL MODE SELECTION

1 This pushbutton returns the 8116A to local manual operation. (NOTE: Pushbutton disabled when LOCAL LOCK-OUT command sent by the controller to the 8116A). In local mode pressing this pushbutton causes the currently selected HP-IB address to be displayed.

2 Program status LEDs. When illuminated, they indicate the following:

- RMT: Indicates REMOTE control and all frontpanel push-buttons are disabled (except LCL).
- ADS: Indicates that the 8116A is being ADDRESSED under program control, although frontpanel push-buttons may be operational depending on whether the RMT LED is lit or unlit.
- SRQ: Indicates that the SERVICE REQUEST has been sent to the controller.

3 Standard mode selection pushbutton and associated LEDs. Repetitive operation of this pushbutton steps through the modes in the sequence indicated by the LED column.

The modes are as follows:

- NORM: NORMAL mode with internal rate generator free-running.
- TRIG: A TRIGGER signal, either at the EXT INPUT connector or via the MANUAL pushbutton, generates one output pulse.
- GATE: A GATE signal, either at the EXT INPUT connector or via the MANUAL pushbutton, generates an output for the duration of that signal.
- E.WID: (Pulse waveform only). The EXTERNAL WIDTH mode allows the signal applied to the EXT INPUT to be shaped in order to determine output pulse width and period.

4 Option mode selection pushbutton and associated LEDs. Repetitive operation steps through the modes in the same sequence as the LED column. The modes are as follows:

- I.SWP: INTERNAL SWEEP. Continuous sweep cycles between the selected start and stop frequency. Frequency increment is logarithmic. Sweep direction always upwards.
- E.SWP: EXTERNAL SWEEP. A trigger signal, either at the EXT INPUT connector or via the MANUAL pushbutton, generates a single sweep between the start and stop frequencies. (Further triggering details are given later in this section under External Triggering/MANUAL descriptions).
- I.BUR: (Pulse waveform excluded). INTERNAL BURST. Preselected number of cycles (1 to 1999) generated continuously. Time between bursts set via RPT key.
- E.BUR: (All waveforms). EXTERNAL BURST. A burst trigger, either at the EXT INPUT connector or via the MANUAL pushbutton, generates a preselected number of output cycles (1 to 1999).

5 Control mode select pushbutton and associated LEDs. Repetitive operation steps through the modes in the same sequence as the LED column. The modes are as follows:

- FM: FREQUENCY MODULATION mode. The 8116A's output can be frequency modulated by applying a voltage to the frontpanel CONTROL INPUT connector.
- AM: AMPLITUDE MODULATION mode. The 8116A's output can be amplitude modulated by applying a voltage to the frontpanel CONTROL INPUT connector.
- PWM: PULSE WIDTH MODULATION mode. The 8116A's output can be pulse width modulated by applying a voltage to the frontpanel CONTROL INPUT connector.
- VCO: VOLTAGE CONTROLLED OSCILLATOR mode. In this mode, a signal applied to the CONTROL INPUT connector determines the 8116A output frequency.

6 Phase pushbutton. In TRIG, GATE and optional BURST modes the start phase may be shifted through -90 degrees in sine or triangle generation using this pushbutton. Haversine or haversine triangle can thus be generated.

7 LINE switch. Power on/off pushbutton.

8 TRIGGER SLOPE pushbuttons. In external triggering modes, the trigger slope of the signal applied to the EXT INPUT connector is selected using these pushbuttons. The currently selected slope is indicated by an illuminated pushbutton LED.

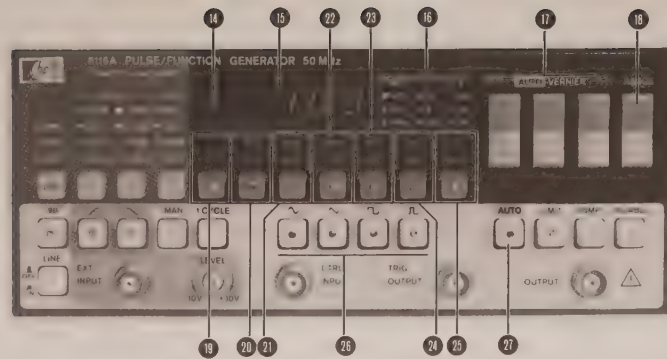
9 EXTERNAL INPUT connector. BNC connector for external trigger signals.

10 LEVEL adjust. Enables the external input trigger level to be adjusted in the range -10 V to 10 V.

11 MANUAL pushbutton. Used to simulate an external trigger signal. In optional sweep modes, it starts a single sweep cycle and resets from stop frequency to start frequency.

12 1 CYCLE pushbutton. (Opt. 001). Pressing this pushbutton generates a single output period in I.BURST and E.BURST modes.

13 CONTROL INPUT connector. BNC connector for external control signals.



PARAMETER/WAVEFORM SELECTION

14 ERROR LED. Indicates erroneous mode settings and incompatible timing settings.

15 Digital display. Indicates numerical value of currently displayed parameter.

16 Units LEDs. Indicates in which units the currently displayed parameter is measured.

17 VERNIER rocker keys. Used to vary parameter values.

18 RANGE rocker key. Used to change the range of the currently selected parameter.

19 to **25** Parameter selection pushbuttons and their associated mnemonics. On pressing a pushbutton, the built-in LED illuminates and the current value of the selected parameter becomes displayed. For each pushbutton, the selected parameter is indicated by an illuminated mnemonic (automatically controlled by the 8116A). Once selected, the parameter value can be varied via the RANGE/VERNIER keys. Individual details of each pushbutton are given in the following:

19 (Option 001). Only active in sweep modes, and selects sweep start frequency (STA) parameter for display and setting.

20 (Option 001). Selected mode determines mnemonic illumination, hence parameter selection. Mnemonics are:

- RPT: REPEAT is illuminated to indicate that "time between bursts" is currently selectable.
- or STP: STOP is illuminated to indicate that "sweep stop frequency" is currently selectable.

21 (Option 001). Selected mode determines mnemonic illumination, hence parameter selection. Mnemonics are:

- BUR: BURST. Illuminated to indicate that "burst number" is currently selectable.
- or SWT: SWEEP TIME. Illuminated to indicate that SWEEP TIME is currently selectable.

22 Selected mode determines mnemonic illumination, hence parameter selection. Mnemonics are:

- MRK: MARKER (Opt. 001). Only illuminated in sweep modes to indicate that "sweep marker frequency" is currently selectable.
- or FRQ: FREQUENCY. Illuminated in all modes, except sweep modes, to indicate that "frequency" is currently selectable.

23 Selected waveform determines mnemonic illumination hence parameter selection. Mnemonics are:

- WID: WIDTH. Illuminated with pulse waveforms selected to indicate that "width" is currently selectable.
- or DTY: DUTY CYCLE. Illuminated when sine, triangle (ramp) or squarewave is selected to indicate that "duty cycle" is currently selectable. (RANGE key and lefthand VERNIER key inactive).

24 Parameter selection is user-dependent. Pressing pushbutton once selects parameter indicated by currently illuminated mnemonic. Pressing the illuminated pushbutton a second time changes parameter selection (mnemonic illumination) e.g. HIGH LEVEL (HIL) to AMPLITUDE (AMP) or vice-versa.

25 Parameter selection is user-dependent. Pressing pushbutton once selects parameter indicated by currently illuminated mnemonic. Pressing the illuminated pushbutton a second time changes parameter selection (mnemonic illumination) e.g. LOW LEVEL (LOL) to OFFSET (OFS) or vice-versa.

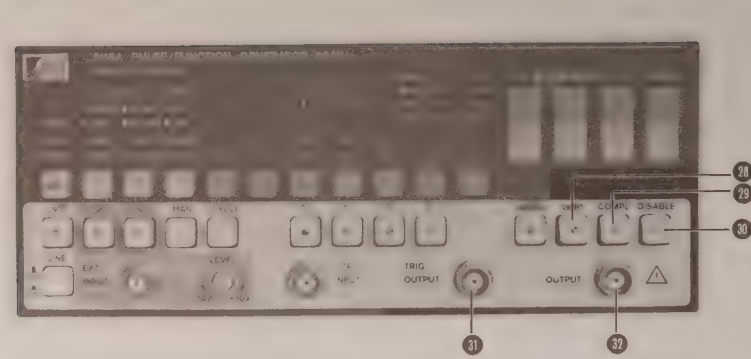
26 Waveform pushbuttons. Select the desired waveform to be generated by the 8116A output. The currently selected waveform is indicated by an illuminated pushbutton LED. Pressing the illuminated pushbutton a second time switches waveforms off for d.c. mode.

27 AUTO pushbutton. In NORM mode only, all parameters can be automatically incremented or decremented with selectable resolution. Pushing the AUTO pushbutton activates the AUTO VERNIER, which can then be started with the selected VERNIER key. Any of 3 conditions causes an AUTO VERNIER "wait" state i.e. AUTO VERNIER active, but no increment/decrement takes place. The conditions are:

1. Timing error exists.
2. At instrument specification limits e.g. frequency 50 MHz.
3. At output level limits set via the LIMIT key.

AUTO VERNIER switch-off is accomplished by any of the following:

1. External trigger input.
2. Pressing any key other than the VERNIER keys.
3. Pressing the AUTO key.



OUTPUT CONTROLS / CONNECTORS

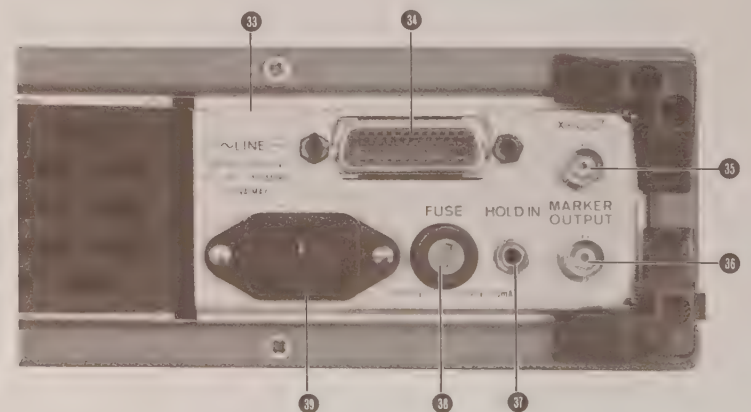
28 LIMIT pushbutton. Maximum high (HIL) and low (LOL) levels into 50 Ohm can be limited to protect the device under test. Pushing the LIMIT key sets the limits to the currently active levels, which cannot be exceeded as long as the LIMIT key is active (pushbutton LED illuminated).

29 COMPLEMENT pushbutton. Provides switch-selectable normal/complement output. When pushbutton LED is illuminated, output is complement.

30 DISABLE pushbutton. Pressing this pushbutton disables the 8116A output. (Disable state indicated by illuminated LED).

31 TRIG OUTPUT connector. BNC connector for providing a trigger output signal.

32 OUTPUT connector. BNC connector for providing the 8116A output signal.



REAR PANEL CONTROLS / CONNECTORS

33 HP-IB device address switch (5 bits A1 to A5).

34 HP-IB connector.

35 X-OUTPUT connector (Opt. 001). Delivers increasing output voltage with logarithmically increasing frequency in sweep mode. 0 V corresponds to start frequency, and slope is 1.5 V/frequency decade. The maximum output voltage is 10 V.

36 MARKER OUTPUT connector (Opt. 001). Provides a TTL compatible voltage with positive-going step at the selected marker frequency in sweep mode.

37 HOLD INPUT connector (Opt. 001). An input signal at this connector causes the 8116A output to hold at that voltage instantaneous to the input signal attaining TTL high. Applicable for sine, triangle and squarewave below 10 Hz.

38 FUSE. Accepts standard fuses to provide instrument protection in case of current overload. A 750 mA slow-blow fuse must be used when operating from a 220/240 V power source. A 1.5 A fuse is used when operating from a 100/120 V power source.

39 LINE. A three pronged receptacle to provide chassis ground through the power cable for operator protection.

Figure 3-1. Controls and Indicators (Option 001 included)

SECTION III OPERATING AND PROGRAMMING

3-1 INTRODUCTION

3-2 The following operating information explains the functions of the controls and indicators of the Model 8116A Pulse/Function Generator. Front and rear panel controls, indicators and connectors are identified and briefly described in Figure 3-1, which should be read before continuing with the following description. Programming information is given at the end of this section.

3-3 SPECIAL OPERATING CONSIDERATIONS



3-4 Read the following four notes before applying power to the Model 8116A.

1. Read the Safety Summary at the beginning of this manual.
2. Ensure the power selector switches are set properly for the power source being used to avoid instrument damage. This can be done by checking the line selection label on the rear panel.

CAUTION: Do not change the LINE SELECT switch setting with the instrument on or with power connected to the rear panel.

3. Ensure that load cannot be overdriven by the 8116A output (16 Vpp into 50 Ω ; 32 Vpp into high impedance).
4. Do not apply an external voltage or electrostatic discharge (ESD) to the output connectors.

3-5 OPERATOR'S CHECKS

3-6 The 8116A performs a 'self check' at power switch-on. During this check, all LED's should be momentarily lit. In the event of a fault, an error code appears in the 8116A frontpanel digital display. The error codes are as follows:

- Indicates that a frontpanel key is jammed in the depressed position.
- E11- Indicates a fault by Auto Vernier/ External Sweep Trigger
- E21- Indicates a fault in the internal rep. rate generator
- E31- Indicates a fault in the internal width circuits. The width setting in pulse mode and the 'time between bursts' in I.BUR mode are affected.
- E41/42- Indicates an output amplifier fault.
- E51-E62 Error indications for dedicated service tests.

3-7 OPERATING INSTRUCTIONS

3-8 Operating modes and parameters can be set on the frontpanel (local operation) or programmed using the HP-IB. The current operating mode is indicated by an illuminated LED in the MODE column on the frontpanel. Parameter selection for the 8116A digital display is indicated by an illuminated pushbutton LED. Similarly, current output waveform is also indicated by an illuminated pushbutton LED.

3-9 At power switch-on, the 8116A performs a self-test and automatically assumes the operating state prevailing at switch-off with the output disabled (DISABLE key LED lit) to protect externally connected devices. The operator should then select the required mode (NORM, TRIG, GATE, E.WID or an Opt. 001 mode when available) and output waveform. Upon selection, the 8116A automatically displays the parameters (mnemonically e.g. FRQ, DTY, AMP, OFS) which can be set within this mode. Parameter keys other than those which select the displayed parameters are not operational.

3-10 Pressing a parameter key then calls the current value of that parameter into the 8116A digital display, and a new value can be set using the RANGE and VERNIER keys. When all parameters are set to the required values, the DISABLE key should then be pressed to enable the output (key LED no longer illuminated).

3-11 In addition to the operating modes, the 8116A offers 4 control modes for modulating or controlling the output signal i.e. FM, AM, PWM, VCO. Table 3-1 shows which control mode can be combined with which operating mode. In the event of the operator selecting an erroneous combination e.g. E.WID and FM, the 8116A automatically displays ERROR and the E.WID and FM LED's will flash. Similarly, in NORM mode, when the operator makes incompatible timing settings (e.g. width greater than frequency) the 8116A displays ERROR.

Table 3-1. Operating/Control Mode Combinations

Mode Modulate	NORM	TRIG	GATE	E.WID	I.SWP	E.SWP	I.BUR	E.BUR
FM	•	•	•	—	•	•	•(2)	•
AM	•	•	•	•(1)	•	•	•(2)	•
PWM	•(1)	•(1)	•(1)	—	•(1)	•(1)	—	•(1)
VCO	•	•	•	—	—	—	•	•

- = All waveforms
- (1) = Pulse waveform only
- (2) = All waveforms except pulse
- = Error combination

3-12 PARAMETERS

3-13 Figure 3-2 (Timing) and Figure 3-3 (Output Levels) illustrate the output signal parameters of the standard 8116A. A description of the various parameter-setting controls is given in Figure 3-1.

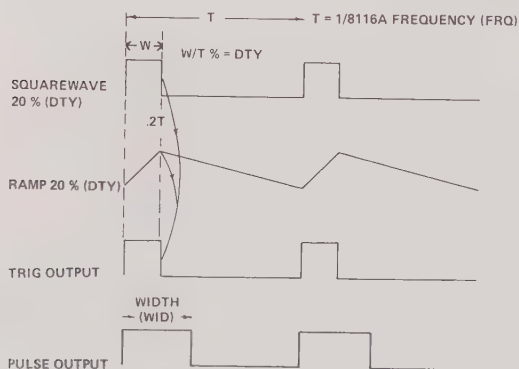


Figure 3-2. Timing Parameters



Figure 3-3. Output Level Parameters

3-14 As described in Figure 3-1, the parameter selection of the amplitude/offset keys is user-dependent. With any change to the HIL or LOL settings, the 8116A automatically calculates and stores the new amplitude and offset values.

3-15 Option 001 mode parameters are explained and illustrated under the respective mode description.

3-16 VERNIER / RANGE OPERATION

3-17 The vernier comprises 3 rocker-switches corresponding to the 3 display digits. Incrementing/decrementing a display digit is accomplished by pressing the upper/lower switch section respectively. (Continuous pressing causes continuous increment/decrement of the related display digit).

3-18 The RANGE key is also a rocker-switch for multiplying/dividing the displayed value by factor 10. For the offset parameter, pressing the key twice provides a quick means of setting 0 V.

3-19 AUTO VERNIER OPERATION

3-20 In NORM mode only, all parameters can be automatically incremented/decremented with selectable resolution. To activate AUTO VERNIER operation, first select the parameter to be incremented/decremented, then press the AUTO key. AUTO VERNIER can now be started by pressing any of the VERNIER keys.

3-21 There are 3 conditions, any of which causes an AUTO VERNIER 'wait' state i.e. AUTO VERNIER active (key LED lit), but no increment/decrement takes place. The conditions are:

1. timing error exists
2. at instrument specification limits e.g. frequency 50 MHz
3. at output level limits set via the LIMIT key.

AUTO VERNIER switch-off is accomplished by any of the following:

- 1. external signal to the EXT INPUT connector
- 2. pressing any key other than the vernier keys
- 3. pressing the AUTO key.

3-22 LIMIT OPERATION

3-23 Maximum high (HIL) and low (LOL) levels into 50 Ohm can be set to protect the device under test. Pushing the LIMIT key sets the currently active high and low levels as the 8116A output limits — which cannot be exceeded as long as LIMIT operation is active (key LED lit).

3-24 EXTERNAL TRIGGERING

3-25 Five pushbuttons, a trigger level adjust and BNC connector (EXT INPUT) facilitate external triggering of the 8116A. The function of the individual pushbuttons in the various external triggering modes is described in the following.

3-26 -90°

3-27 With TRIG, GATE or E.BUR (Opt. 001) mode selected, and output waveform set to sine or triangle, pressing this pushbutton shifts the start phase to -90°. As a result, haversine and havertriangle signals can be generated by the 8116A.

3-28 Trigger Slopes

3-29 Positive or negative slope is selectable for triggering on the signal applied to the EXT INPUT connector. With no slope selected (both key LED's off), the EXT INPUT is switched off.

3-30 Triggering level on the selected slope is set via the LEVEL adjust.

3-31 Note that in E.SWP mode (Opt. 001), two trigger pulses may be required. If the 8116A is not set to the start frequency (STA) i.e. STA key LED not illuminated, the first trigger pulse sets the 8116A to the STA frequency. The second trigger pulse then starts the sweep.

3-32 MANUAL

3-33 In external trigger modes, the 8116A can be triggered manually via the MAN pushbutton:

TRIG Mode. Each operation of the MAN key generates one output cycle, cycle time being determined by the 8116A frequency setting.

GATE Mode. The 8116A outputs continuously for as long as the MAN key is depressed. Frequency is determined by the 8116A frequency setting.

E.SWP Mode (Opt. 001). MAN key operation starts the sweep only if the 8116A is set to the start frequency (STA) i.e. STA key LED illuminated. Otherwise, MAN key must be pressed twice; the first time to reset the 8116A to STA, the second to start the sweep.

E.BUR Mode (Opt. 001). Each operation of the MAN key triggers a burst output.

3-34 1 CYCLE (OPTION 001)

3-35 In E.BUR and I.BUR modes, each operation of this key generates a single cycle at the 8116A output.

3-36 STANDARD PARAMETER SET

3-37 The Standard Parameter Set is available for two reasons. Firstly it serves to overcome RAM corruption, should it occur as a result of battery charge deterioration, by giving an error-free display at switch-on. Secondly, when incompatible mode selection causes an error condition (i.e. E.WID and Sine), the instrument may be switched OFF then ON again to revert to the Standard Parameter Set, thus overcoming any condition previously displayed. The Standard Parameter Set is as follows:

NORM ON
FRQ (active) 1.00 kHz
DTY 50 %
HIL +0.5 V
LOL -0.5 V
..... ON

Selecting I.SWP mode gives:

STA 1.00 kHz
STP 100 kHz
SWT 50 ms
MRK 1.00 kHz
DTY 50 %
HIL +0.5 V
LOL -0.5 V

Selecting I.BUR mode gives:

RPT	100 ms
BUR	1
FRQ	1.00 kHz
DTY	50 %
HIL	+0.5 V
LOL	-0.5 V

Selecting E.BUR withdraws the RPT parameter from the display mnemonics.

Selecting Pulse mode makes WID available (500 μ s):

The Standard Parameter Set can be accessed when the 8116A is operating on the HP-IB by sending the command:

CLR 7 (BASIC) CLEAR 7 (HPL)

3-38 CONTROL MODES

3-39 The 8116A output signal can be modulated (AM, FM, PWM) or controlled (VCO) by applying a signal to the CTRL INPUT connector. Table 3-1 indicates the permitted operating mode/control mode combination, a brief description of each control mode being given in the following. For specification details in each mode — see Table 1-2.

3-40 FREQUENCY MODULATION (FM)

3-41 The 8116A's output can be frequency modulated by applying a signal to the CTRL INPUT connector.

3-42 AMPLITUDE MODULATION (AM)

3-43 The 8116A's output can be amplitude modulated by applying a signal to the CTRL INPUT connector. A ground symmetrical modulating signal provides a modulation of 0–100 %. 200 % modulation (DSBSC) can also be obtained. Figure 3-4 illustrates 100 % modulation and DSBSC.

3-44 PULSE WIDTH MODULATION (PWM)

3-45 In pulse mode, the 8116A's output can be pulse width modulated by applying a signal to the CTRL INPUT connector. Pulse width modulation is available in any one of 8 non-overlapping decade ranges, as illustrated in Figure 3-5.

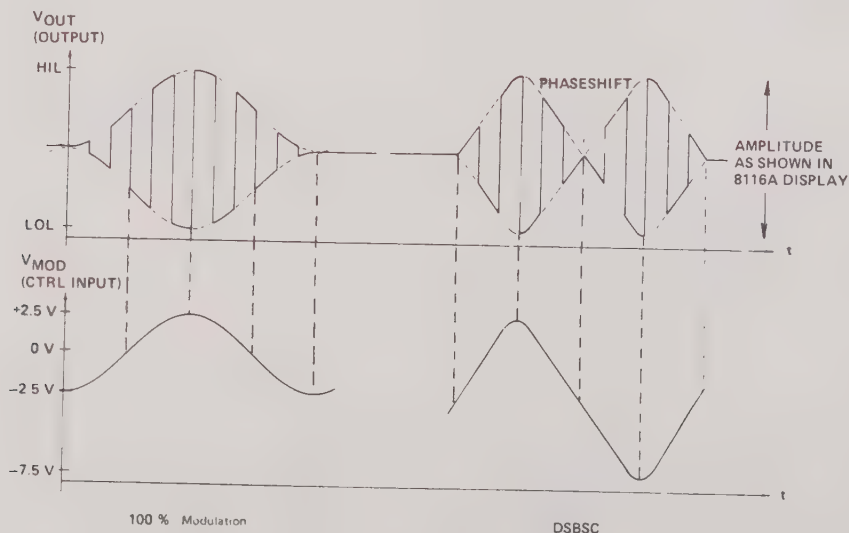


Figure 3-4. Amplitude Modulation

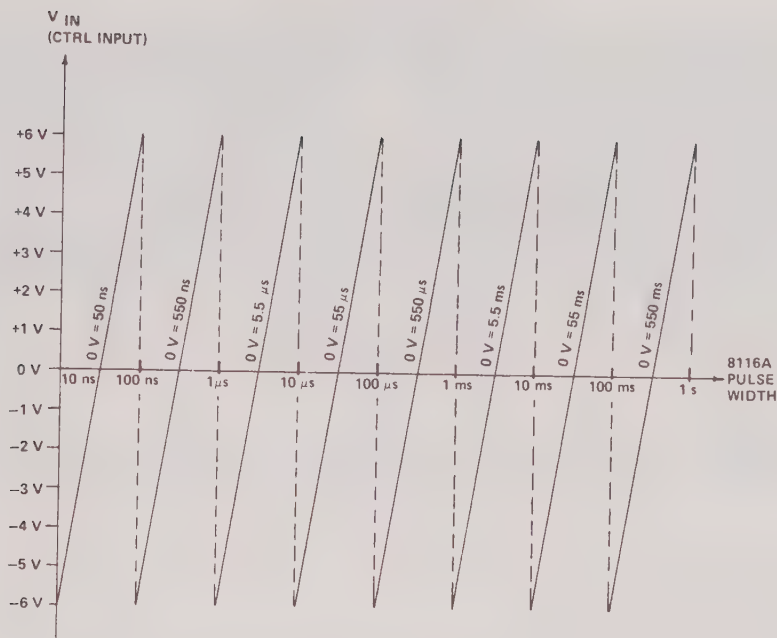


Figure 3-5. PWM Characteristics

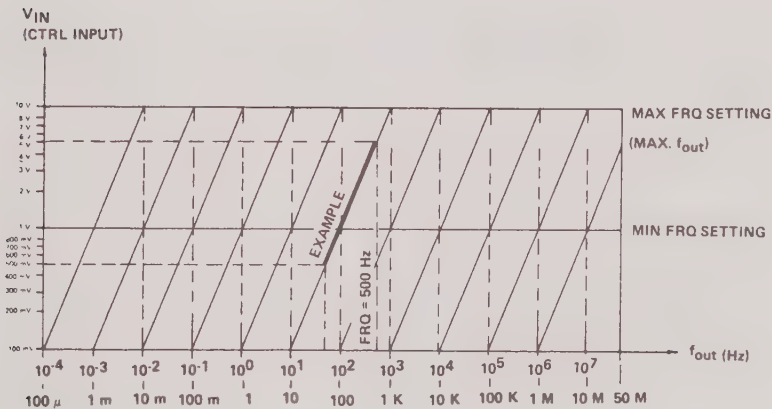


Figure 3-6. VCO Characteristics

3-46 VOLTAGE CONTROLLED OSCILLATOR (VCO)

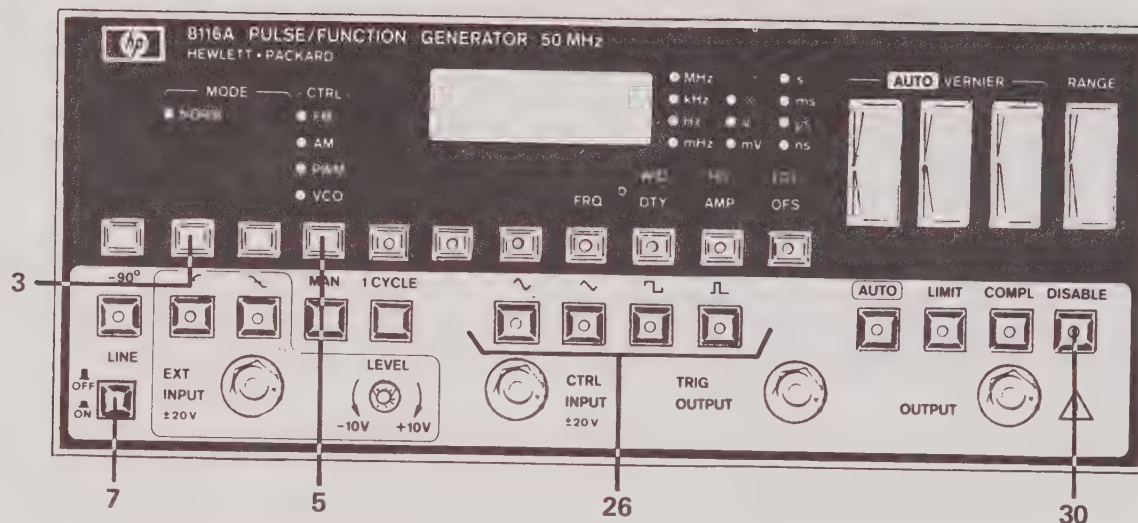
3-47 In this mode, a signal applied to the CTRL INPUT connector determines the output frequency. Output frequency range is a maximum 1:100 as shown in Figure 3-6.

Range selection is automatically determined by the 8116A frequency (FRQ) setting, the selected range being that whose upper decade brackets the FRQ setting. Figure 3-6 gives a range selection example for an FRQ setting of 500 Hz.

3-48 OPERATING MODES

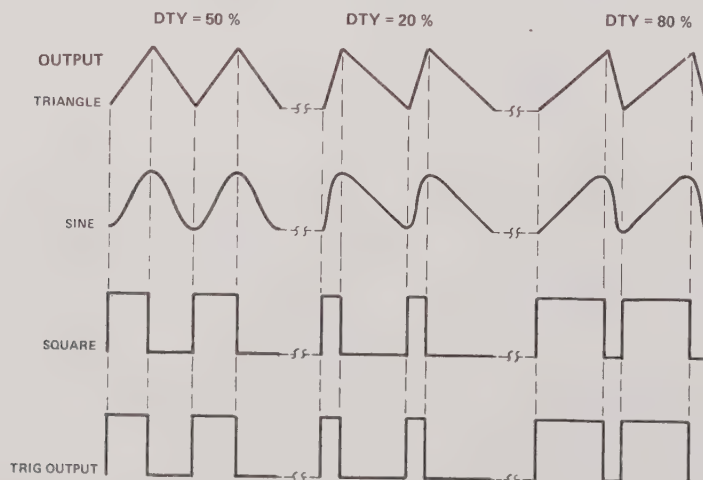
3-49 Each of the 8 operating modes (standard and Opt. 001) is described briefly. For each mode, a short procedure is given to aid quick mode entry together with timing diagrams to illustrate the various outputs in the described mode. Each 8116A operating mode illustration highlights the parameter mnemonics, hence parameter settings for the presented mode.

NORM MODE

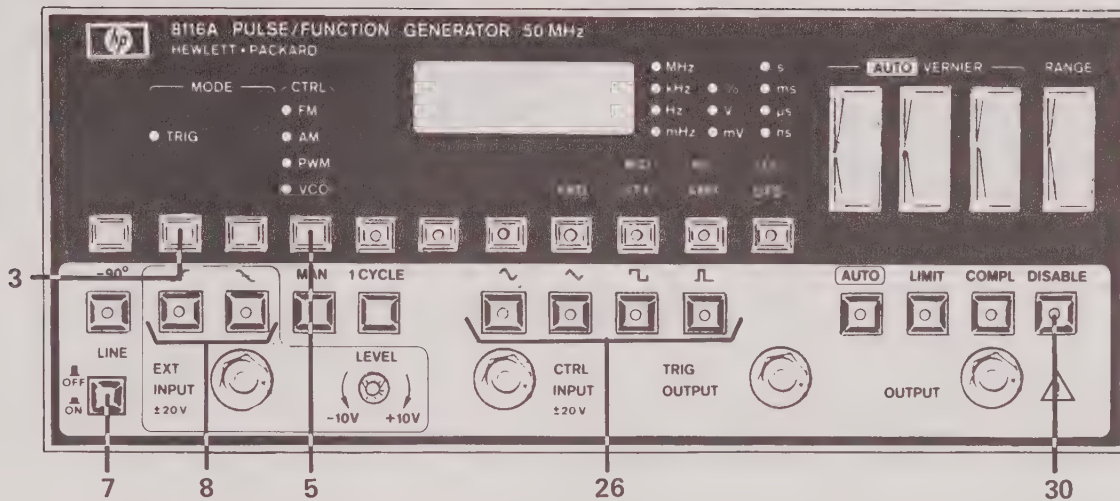


NOTE: For parameter specifications, see Table 1–2.

1. Set the LINE switch (7) to the ON position.
2. Select NORM mode (if necessary) via key (3). Standard modes are stepped-through by repetitive operation of this key.
3. Select the desired waveform at row (26). The parameter menu will automatically be illuminated as shown above (WID only illuminated if pulse waveform selected; also, although HIL, LOL, AMP and OFS can all be selected, only HIL/LOL or AMP/OFS will be illuminated at any one point in time — see Figure 3–1 description).
4. Select each parameter, in turn, via its associated key, and set it to the desired value using the RANGE/VERNIER keys and the digital display.
5. If a modulated output is required, select the desired modulation via key (5), and apply the modulating signal to the CTRL INPUT connector.
6. Press key (30) to enable the 8116A output. Key LED should no longer be illuminated. The following timing diagram illustrates the outputs in NORM mode.



TRIG MODE



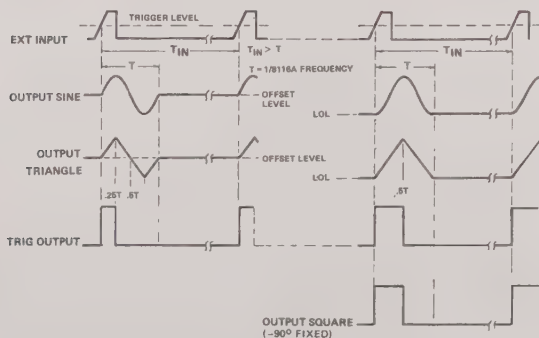
NOTE: For parameter specifications, see Table 1–2.

1. Set the LINE switch (7) to the ON position.
2. Select TRIG mode via key (3). Standard modes are stepped-through by repetitive operation of this key.
3. Select the desired waveform at row (26). The parameter menu will automatically be illuminated, this being a combination of those shown above, e.g. WID only illuminated if pulse waveform selected.
4. Select each parameter, in turn, via its associated key, and set it to the desired value using the RANGE/VERNIER keys and the digital display. Note that the frequency setting should be set less than the frequency of the trigger signal.
5. If triggering is by an external signal, select the trigger slope at (8), and apply the trigger signal to the EXT INPUT connector. Triggering can also be simulated by press the MAN key.
6. If a modulated output is required, select the desired modulation via key (5), and apply the modulating signal to the CTRL INPUT connector.
7. Press key (30) to enable the 8116A output. This key LED should no longer be illuminated. The following timing diagrams illustrate some outputs in TRIG mode.

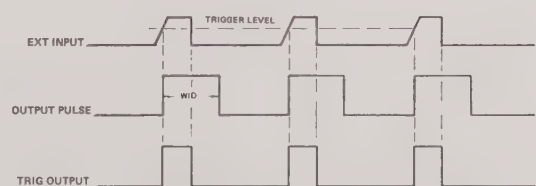
FUNCTIONS

0° START PHASE
(DTY = 50 %)

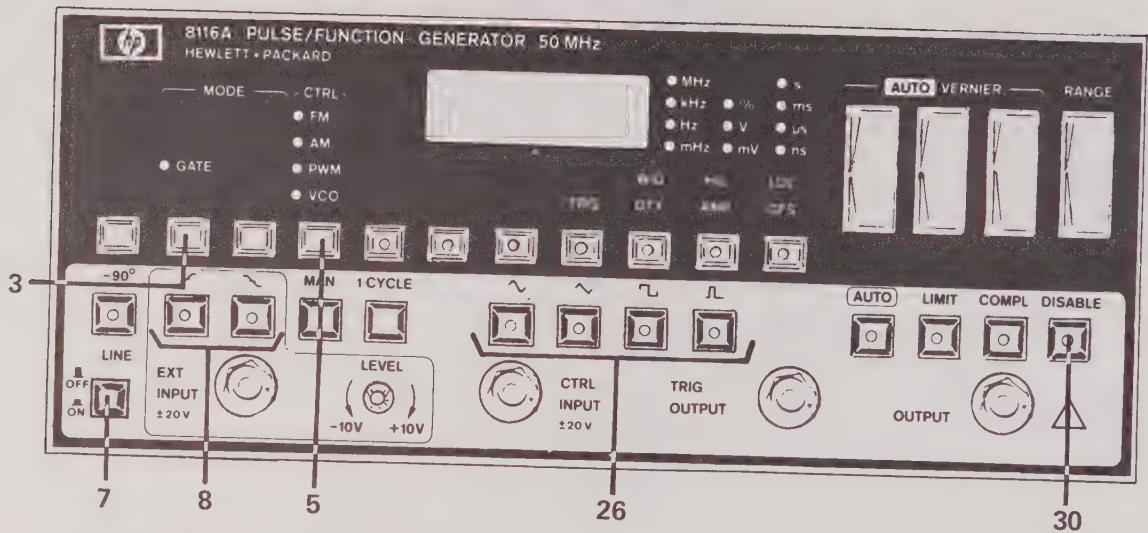
–90° START PHASE
(DTY = 50 %)



PULSE

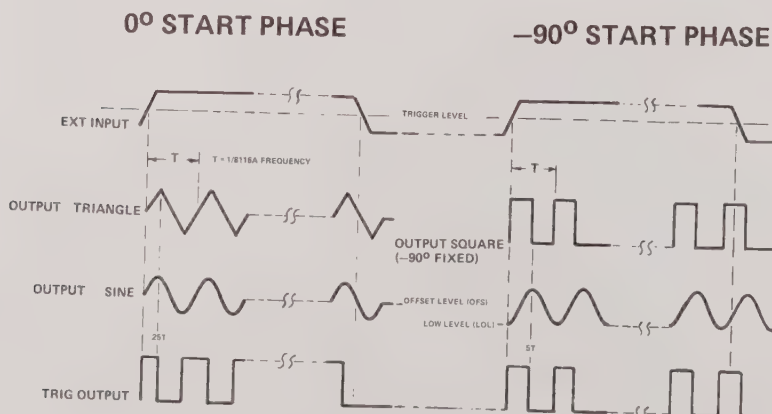


GATE MODE

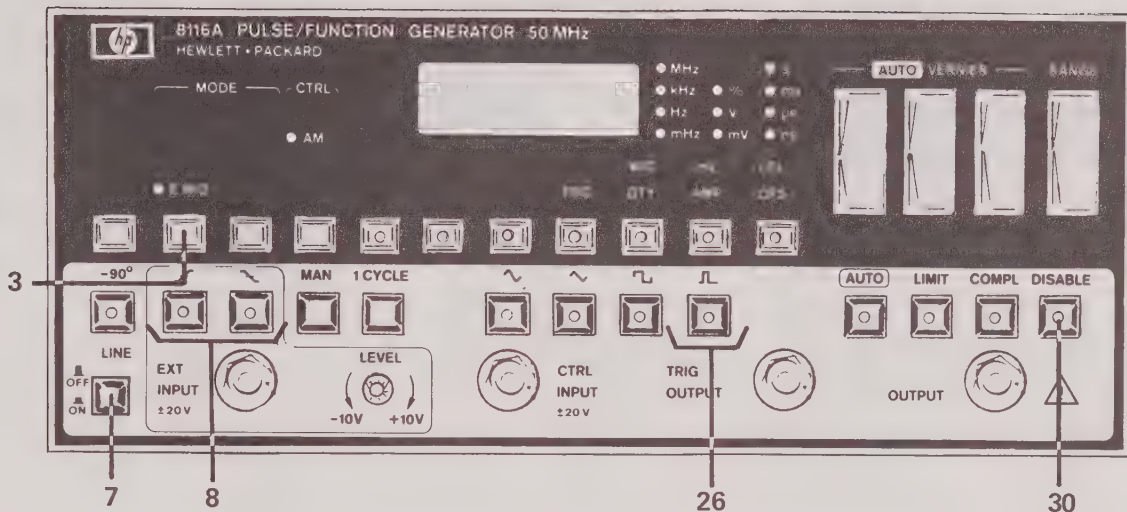


NOTE: For parameter specifications, see Table 1-2.

1. Set the LINE switch (7) to the ON position.
2. Select GATE mode via key (3). Standard modes are stepped — through by repetitive operation of this key.
3. Select the desired waveform at row (26). The parameter menu will automatically be illuminated, this being a combination of those shown above e.g. WID only illuminated if pulse waveform selected.
4. Select each parameter, in turn, and set it to the desired value using the RANGE/VERNIER keys and the digital display.
5. If gating by an external signal, select the trigger slope at (8), and apply the gate signal to the EXT INPUT connector.
6. If a modulated output is required, select the desired modulation via key (5), and apply the modulating signal to the CTRL INPUT connector.
7. Press key (30) to enable the 8116A output. This key LED should no longer be illuminated. The following timing diagrams illustrate some outputs in Gate mode.

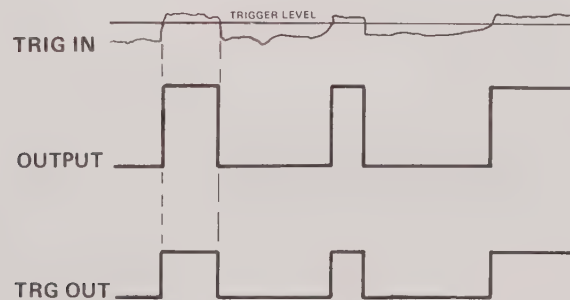


E.WID

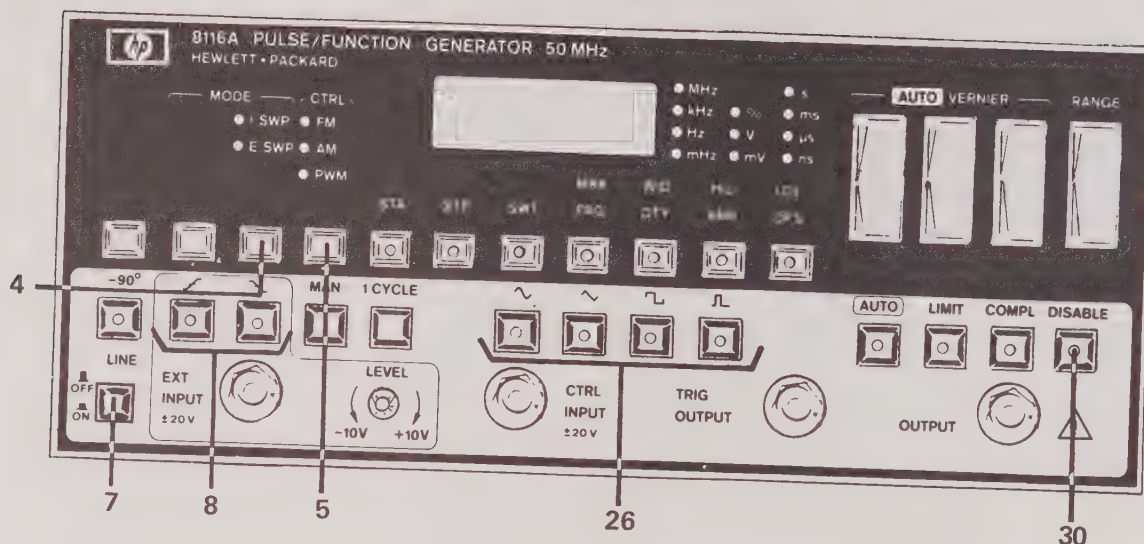


NOTE: For parameter specifications, see Table 1–2.

1. Set the LINE switch (7) to the ON position.
2. Select E.WID mode via key (3). Standard modes are stepped — through by repetitive operation of this key.
3. Select pulse waveform at row (26). The parameter menu will automatically be illuminated, i.e. AMP/OFS or HIL/LOL — see Figure 3–1 description of these parameter keys.
4. Select each parameter in turn, and set it to the desired value using the RANGE/VERNIER keys and the digital display.
5. Apply the external signal to be shaped to the EXT INPUT connector and select the trigger slope at (8).
6. Press key (30) to enable the 8116A output. This key LED should no longer be illuminated. A timing diagram illustrating an output in this mode is given in the following.



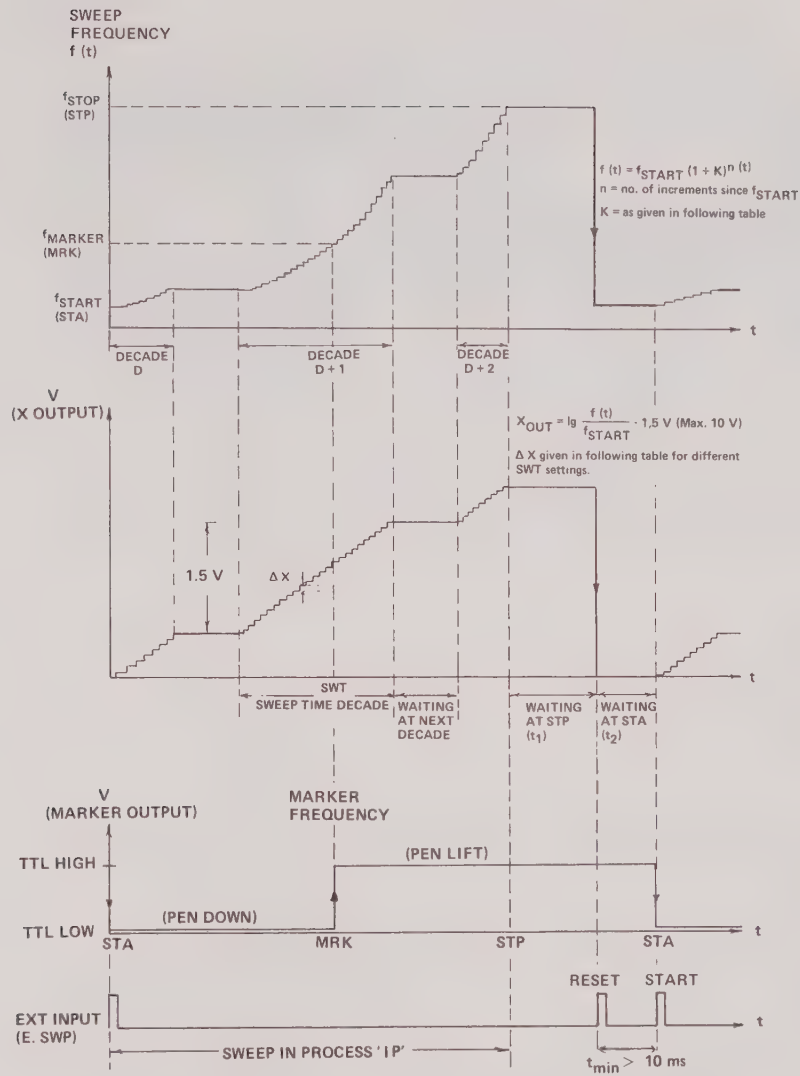
SWEEP MODES



NOTE: For parameter specifications, see Table 1—2.

1. Set the LINE switch (7) to the ON position.
2. Select a sweep mode (Internal or External) via key (4). Repetitive operation of this key steps through the Opt. 001 modes.
3. Select the desired waveform at row (26). The parameter menu will be automatically illuminated in mnemonic form, e.g. AMP for amplitude. The sweep-related parameters (STA, STP, SWT, MRK) are illustrated in the following timing diagrams.
4. Select each parameter, in turn, and set it to the required value using the RANGE/VERNIER keys and the digital display.
5. If triggering via an external signal (E. SWP), select the trigger slope at (8), and apply the trigger signal to the EXT INPUT connector. Triggering can also be simulated by pressing the MAN key. In either case, note the trigger requirements i.e. a 'reset' pulse is required prior to the 'start' pulse if the 8116A is not currently set to the STA frequency.
6. If a modulated output is required, select modulation via key (5) and apply the modulating signal to the CTRL INPUT connector.
7. Press key (30) to enable the 8116A output. The key LED should no longer be illuminated. The following timing diagrams illustrate the 8116A outputs in sweep modes.

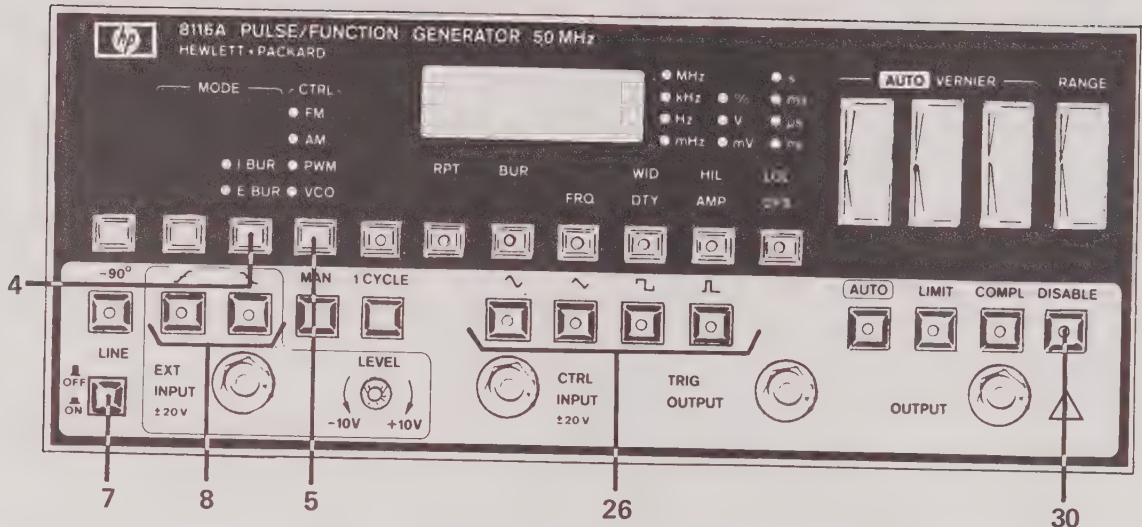
- NOTES:**
1. When external sweep is in process ('IP' in display), RANGE/VERNIER keys are disabled (also disabled during period 't_i' in following timing diagrams).
 2. Sweep (I. SWP and E. SWP) can be interrupted by pressing any key other than RANGE/VERNIER/MAN/I CYCLE keys.



SWT (Sweep time/ Decade)	K Factor	η DEC (increments/ decade)	ΔX (X_{OUT} / increment)
10 ms	0.0625	38	40 mV
20 ms	0.03125	75	20 mV
50 ms	0.015625	149	10 mV
100 ms	0.015625	149	10 mV
200 ms	0.015625	149	10 mV
500 ms	0.015625	149	10 mV
1 s	0.015625	149	10 mV
2 s	0.015625	149	10 mV
5 s	0.015625	149	10 mV
10 s	0.015625	149	10 mV
20 s	0.015625	149	10 mV
50 s	0.015625	149	10 mV
100 s	0.015625	149	10 mV
200 s	0.015625	149	10 mV
500 s	0.015625	149	10 mV

SWT is set in multiples of 1, 2 or 5 via the VERNIER keys, or in decades by the RANGE key.

BURST MODES



NOTE: For parameter specifications, see Table 1–2.

1. Set the LINE switch (7) to the ON position.
2. Select a burst mode (Internal or External) via key (4). Repetitive operation of this key steps through the Opt. 001 modes.
3. Select the desired waveform at row (26) (Pulse mode not available with I. BUR). The parameter menu will automatically be displayed in mnemonic form. The burst-related parameters (RPT, BUR) are defined in the following timing diagrams.
4. Select each parameter in turn, and set it to the required value using the RANGE/VERNIER keys and the digital display.
5. If triggering via an external signal (E.BUR), select the trigger slope at (8), and apply the trigger signal to the EXT INPUT connector.
6. If a modulated output is required, select modulation via key (5), and apply the modulating signal to the CTRL INPUT connector. See Table 3–1 for burst/control mode combinations.
7. Press key (30) to enable the 8116A output. The key LED should no longer be illuminated. The following timing diagrams illustrate the 8116A output in burst modes.

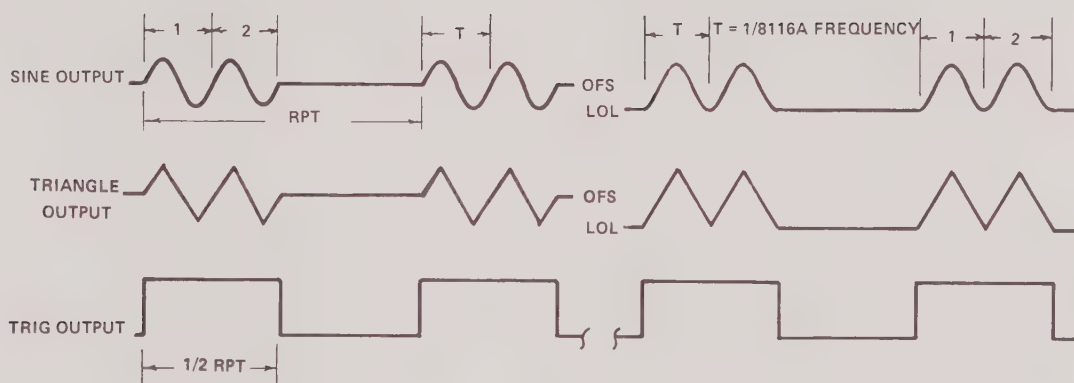
I. BUR

0° START PHASE

(BUR = 2; DTY = 50 %)

-90° START PHASE

(BUR = 2; DTY = 50 %)



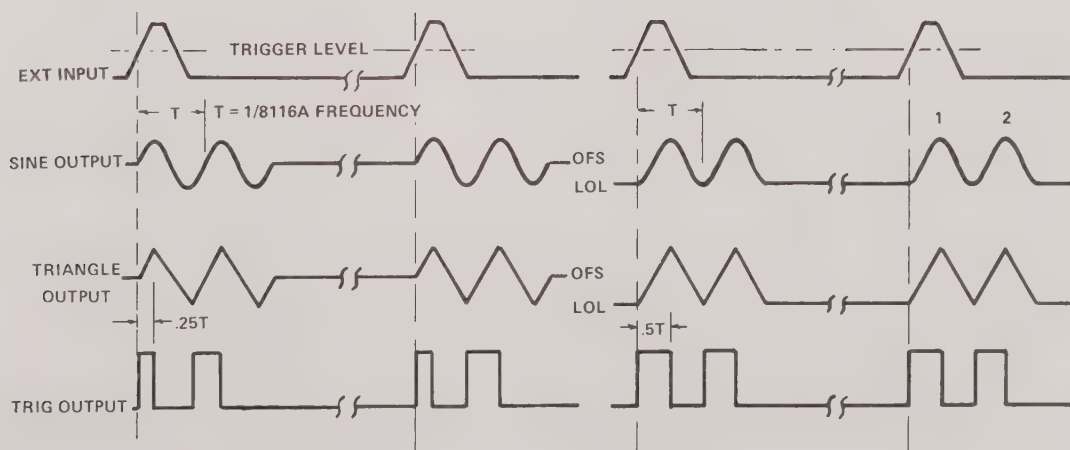
E. BUR

0° START PHASE

(BUR = 2; DTY = 50 %)

-90° START PHASE

(BUR = 2; DTY = 50 %)



3-50 PROGRAMMING

3-51 General

3-52 The 8116A operates on the HP-IB as follows:

Listens: to messages from the HP-IB system controller. In this state, all modes and parameters, except external trigger LEVEL adjust, are programmable. Also provided are special HP-IB only functions to aid the programmer.

Talks: provides error messages and reports operating parameters.

3-53 As shown in Figure 3-13, the bus lines are as follows (all use negative logic):

8-bit data bus (lines DIO 1 to 8)

handshake lines — DAV (data valid), NRFD (not ready for data), NDAC (data not accepted).

control lines — IFC (interface clear), ATN (attention), SRQ (service request), REN (remote enable), EOI (end or identify).

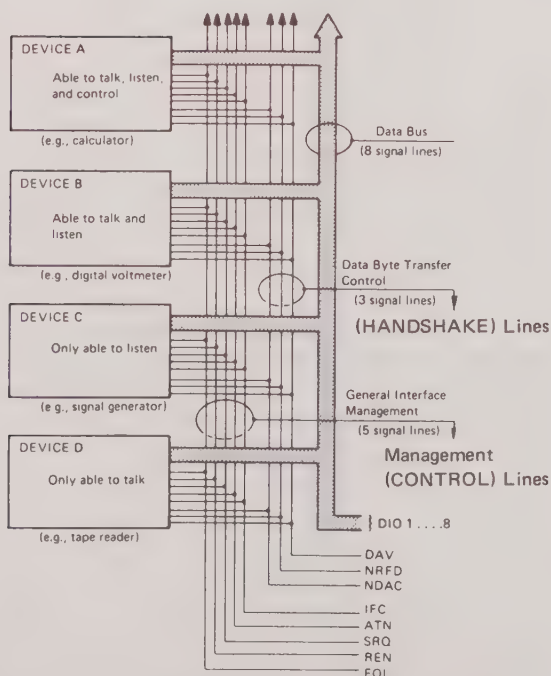


Figure 3-13. Interface Connections + Bus Structure

The 8116A uses all lines on the bus, terminations, logic levels and pinouts being described in Section II. In this manual, bus information will generally be restricted to 8116A specifics. For this reason, handshake lines are not discussed, and control lines are only mentioned in connection with specific 8116A activity. Permissible codes are presented in Table 3-9. For detailed bus information, refer to any of the following publications:

IEEE	Interface Standard 488-1975
ANSI	Interface Standard MC1.1.
HP	Publication 59401-90030
HP	Publication 5952-0058

3-54 Address Assignment

3-55 The 8116A's HP-IB address is determined by an internal storage register. This register is initialised upon power turn-on by reading the address bits A1 through A5 from the HP-IB ADDRESS switch on the rear panel. Note that this switch is factory preset to decimal 16. To change the address, first change the bit settings on the rear panel switch, then press the LCL key to read the new address into the register (alternatively, switch power off and on). Table 3-2 lists all the possible addresses on the bus.

3-56 The current HP-IB address can be checked by pressing the LCL key. The address is then displayed in decimal form.

3-57 Talk and listen addresses are transmitted by the system controller over the data bus with the ATN line true. When an instrument recognizes its address, it will respond accordingly i.e. listen if listen address has been transmitted; talk if talk address has been transmitted. When allocating addresses, make sure no two instruments have the same address. To program an address, set ATN true and arrange that the ASCII character derived from Table 3-2 appears on the bus. For deaddressing, use UNL, UNT commands (or address another device).

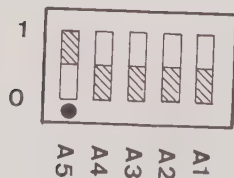
IMPORTANT!

Users of instruments with serial numbers 2124G01235 or lower should perform the following check:

Switch 8116A ON, and select E.WID and sine ~. This combination will give an ERROR condition. Switch the instrument OFF and ON again. Select WID. If the value displayed is 100 μ s, it will be necessary to refer to SECTION 7 — Backdating before proceeding with any programming. If the display reads 500 μ s, proceed with this section.

Table 3-2. Available Addresses (ATN true)

Data bus (DIO lines)							Address in ASCII		
Fixed		Selectable					Talk	Listen	
8	7	6	5	4	3	2 1 DEC			
0	T	L	0	0	0	0 0	@	Space	
0	T	L	0	0	0	0 1	A	!	
0	T	L	0	0	0	1 0	B	"	
0	T	L	0	0	0	1 1	C	#	
0	T	L	0	0	1	0 0	D	\$	
0	T	L	0	0	1	0 1	E	%	
0	T	L	0	0	1	1 0	F	&	
0	T	L	0	0	1	1 1	G	'	
0	T	L	0	1	0	0 0	H	(	
0	T	L	0	1	0	0 1	I	)	
0	T	L	0	1	0	1 0	J	*	
0	T	L	0	1	0	1 1	K	+	
0	T	L	0	1	1	0 0	L	,	
0	T	L	0	1	1	0 1	M	-	
0	T	L	0	1	1	1 0	N	.	
0	T	L	0	1	1	1 1	O	/	
0	T	L	1	0	0	0 0	P	0	← 8116A set to this address at factory.
0	T	L	1	0	0	0 1	Q	1	
0	T	L	1	0	0	1 0	R	2	
0	T	L	1	0	0	1 1	S	3	
0	T	L	1	0	1	0 0	T	4	← Usually con- troller address!
0	T	L	1	0	1	0 1	U	5	
0	T	L	1	0	1	1 0	V	6	
0	T	L	1	0	1	1 1	W	7	
0	T	L	1	1	0	0 0	X	8	
0	T	L	1	1	0	0 1	Y	9	
0	T	L	1	1	0	1 0	Z	:	
0	T	L	1	1	0	1 1	[	;	
0	T	L	1	1	1	0 0	\	<	
0	T	L	1	1	1	0 1	]	=	
0	T	L	1	1	1	1 0	^	>	
0	T	L	1	1	1	1 1	—	?	← Forbidden set- ting! UNT, UNL commands.



Selector on 8116A
rear panel (factory
setting).

L = 1 for listen address, 0 for talk address
T = 1 for talk address, 0 for listen address

3-58 Remote Operator's Checks

3-59 A quick check of the 8116A's talk/listen functions is provided in Figure 3-14. [Program example assumes the 8116A address is set to the factory value 16].

3-60 Also implemented in the 8116A is a RAM/hardware self-test routine initialized via HP-IB message 'EST' — see Figure 3-15. Tested hardware functions include:

- Repetition rate generator
- Width generator
- Shaper/output amplifier
- Auto vernier

3-61 In the event of fault detection, the 8116A sets bits 4 and 7 (System Failure and Service Request) of its HP-IB Status Byte to '1'. More information on this status byte is given later under 'Error Reporting'.

3-62 Mode and Parameter Settings (Listener Function)

3-63 When the 8116A is in remote and has been listen addressed, it accepts messages which change parameter and/or mode settings. Each mode and parameter-setting message comprises either a number of ASCII data bytes transmitted serially over the data lines with ATN false or an HP-IB Universal Command. The coding for the bytes is given in Table 3-3, which summarizes all mode/parameter-setting messages. Note: The HP-IB program code syntax for parameters is identical to the front panel mnemonics e.g. AMP for amplitude. Reference may be made to Table 3-9 to convert each ASCII byte to a bit pattern on the data bus.

Figure 3-14. TALK/LISTEN FUNCTION CHECK

Flowchart	HPL Statements (HP 9826 Desktop Computer)	BASIC Statements (HP 85 Desktop Computer)	Visual Indicators
<pre> graph TD START([START]) --> SetREN[Set REN line true to ensure 8116A is in remote enable state] SetREN --> Program[Program 8116A frequency to 1 Hz] Program --> Interrogate[Interrogate 8116A frequency setting] Interrogate --> Print[Print 8116A frequency] Print --> END([END]) </pre>	<pre> rem 716 wrt 716, "FRQ 1 Hz" wrt 716, "IFRQ" dim A\$ [12] red 716, A\$ prt A\$ </pre>	<pre> REMOTE 716 OUTPUT 716; "FRQ 1 Hz" OUTPUT 716; "IFRQ" ENTER 716; A\$ PRINT A\$ </pre>	RMT LED on RMT and ADS LED's on. FRQ key LED on. '1.00 Hz' displayed. Printout "FRQ 1.00 Hz"

Figure 3-15. RAM / HARDWARE CHECK

Flowchart	HPL Statement (HP 9826)	BASIC Statement (HP 85)
<pre> graph TD START([START]) --> SetREN[Set REN line true to ensure 8116A is in remote enable state] SetREN --> Program[Program 8116A to execute self-test] Program --> ReadStatus[Read status of 8116A HP-IB Status Register, and store decimal value of status byte in B] ReadStatus --> Decision{B # 1} Decision -- no --> CONTINUE([CONTINUE]) Decision -- yes --> PrintFault[Print "8116A FAULT"] PrintFault --> END([END]) </pre>	<pre> rem 716 wrt 716, "EST" rds (716) -> A IF B (BIT 3): PRT "8116A FAULT" </pre>	<pre> REMOTE 716 OUTPUT 716; "EST" A=SPOLL (716) B=BIT (A, 3) IF BIT = 1 THEN PRINT "8116A FAULT" </pre>

3-64 When programming, it is possible to put the instrument into an error condition in the same way as when under local (frontpanel) control.

For example:

current settings: HIL 2.5V, LOL 1.5V
FRQ 10kHz, WID 10 μ s

program settings: LOL 3.0V, FRQ 1MHz

Both of the new program settings will put the instrument into an error condition. However, if BOTH HIL and LOL and/or FRQ and WID values are re-programmed in the same string, e.g.

HIL 3.5V, LOL 3.0V
FRQ 1MHz, WID 100ns

no error will occur. The above is applicable to HIL, LOL, AMP, OFS, FRQ, WID, DTY, STA and STP. In the event of an error occurring, a "Service Request" will be sent to the controller. More information on parameter programming sequence is given under "Error Reporting".

3-65 The 8116A does not necessarily respond to program codes in the order in which they are sent. The 'Universal' messages such as operating and control modes, waveform and trigger slope selections are processed before parameter data. For some applications, the operator will require a parameter to be changed before, say, an operating mode. To achieve this, the CRLF ("") message must be sent immediately after the parameter value, and the operating mode data sent in a separate string. The following examples illustrate this point.

10 OUTPUT 716; "TO, HIL 4.00V, LOL -1.00V, M1"

In this case, messages T0 and M1 will be processed before the HIL and LOL data.

10 OUTPUT 716; "HIL 4.00V, LOL -1.00V"
20 OUTPUT 716; "T0, M1"

In this case, HIL and LOL settings will be processed before T0 and M1. Should the operator require a time interval of, say, 550 ms before line 20 is executed, the input to the controller should look like this:

10 OUTPUT 716; "HIL 4.00V, LOL -1.00V"
20 WAIT 550
30 OUTPUT 716; "T0, M1"
40 END

The End of String message (EOS) must be the ASCII character sequence CRLF or the bus END command (EOI true and ATN false).

3-66 Mode and Parameter Settings (Talker Function)

3-67 The 8116A can send data messages, concerning its mode/parameter settings, when in remote and addressed to talk. The available output modes are:

Learn String
Interrogate Function
Status

Table 3-4 lists the ASCII commands associated with each of these modes.

3-68 The Learn String message ("CST") consists of an 89 (161 for Opt. 001 instruments) character ASCII string representing the 8116A current settings. The order in which data is presented is always the same, the exception to the rule being whether HIL/LOL or OFS/AMP is currently active on the frontpanel. Below are examples to show what the Learn String messages look like.

CST

M1,CT0,T1,W1,H0,A0,L0,C0,D1,BUR
001 #, RPT 100 MS, STA 1.00 KHZ
,STP 100 KHZ, SWT 50.0 MS, MRK 1.0
0 KHZ, FRQ 1.00 KHZ, DTY 50 %, WID
100 US, AMP 1.00 V, OFS 100 MV

AMP and OFS active

CST

M1,CT0,T1,W1,H0,A0,L0,C0,D1,BUR
0001 #, RPT 100 MS, STA 1.00 KHZ
,STP 100 KHZ, SWT 50.0 MS, MRK 1.0
0 KHZ, FRQ 1.00 KHZ, DTY 50 %, WID
100 US, HIL 0.30 V, LOL -0.70 V

HIL and LOL active

3-69 The Status Function sends an 8-bit byte in response to a Serial Poll. Bits 5 and 6 of bits 1 through 8 are allocated for current operating conditions:

Bit 5 set to one (16 dec) indicates
"Autovernier in Progress"

Bit 6 set one (32 dec) indicates
"Sweep in Progress"

A more detailed description of the Status Byte is given under 'Error Reporting'.

3-70 In all talker modes, the 8116A terminates its data message with the ASCII character sequence CR/LF.

Table 3-3. Mode / Parameter Messages (listen function)

MESSAGE	MNEMONICS ASCII CODE	ASCII CODE DELIMITERS	SAMPLE STATEMENTS
Operating Modes			
select NORM	M1		
select TRIG	M2		
select GATE	M3		
select E.WID	M4		
select I.SWP	M5		
select E.SWP	M6	} Opt. 001	
select I.BUR	M7		
select E.BUR	M8		
Control Modes			
off	CT0		
select FM	CT1		
select AM	CT2		
select PWM	CT3		
select VCO	CT4		
Trigger Slope			
off	T0		
select positive slope	T1		
select negative slope	T2		
Haversine (-90°)			
off	H0		
on	H1		
Waveform			
off (dc)	W0		
select sine	W1		
select triangle	W2		
select square	W3		
select pulse	W4		
Parameters			
set frequency	FRQ	MZ = Millihertz HZ = Hertz KHZ = Kilohertz MHZ = Megahertz	
set duty cycle	DTY	%	
set width	WID	NS = Nanoseconds US = Microseconds MS = Milliseconds	
set amplitude	AMP	MV = Millivolts V = Volts	
set offset	OFS	MV = Millivolts V = Volts	

HPL
(HP 9826)BASIC
(HP 85)

wrt 716, "M2, T1, W2" OUTPUT 716;
"M2, T1, W2"

selects trigger mode with triggering
on the positive slope of external
signal, and triangle output.

Table 3-3. Mode / Parameter Messages (cont'd)

MESSAGE	MNEMONICS ASCII CODE	ASCII CODE DELIMITERS	SAMPLE STATEMENTS	
set high level	HIL	V = Volts	HPL	BASIC
set low level	LOL	V = Volts	wrt 716, "FRQ 1 KHZ, DTY 50 %, BUR 7 #, RPT 100 MS"	OUTPUT 716;"FRQ 1 KHZ, DTY 50 %, BUR 7 #, RPT 100 MS"
			sets frequency to 1 kHz, duty cycle to 50 %, burst number to 7 and time between burst 'starts' to 100ms	
set burst number	BUR	#		
set repetition rate for internal burst	RPT	NS = Nanoseconds US = Microseconds MS = Milliseconds		
set sweep start frequency	STA	MZ = Millihertz HZ = Hertz KHZ = Kilohertz MHZ = Megahertz		
set sweep stop frequency	STP	MZ = Millihertz HZ = Hertz KHZ = Kilohertz MHZ = Megahertz		
set sweep marker frequency	MRK	MZ = Millihertz HZ = Hertz KHZ = Kilohertz MHZ = Megahertz		
set sweep time	SWT	S = Seconds MS = Milliseconds		
Sign				
+	+			
-	-			
Decimal point	.			
Limit				
off	LO			
on	LI			
Complement				
off (normal output)	C0			
on	C1			

Table 3—3. Mode / Parameter Messages (cont'd)

MESSAGE	MNEMONICS ASCII CODE	ASCII CODE DELIMITERS	SAMPLE STATEMENTS	
Disable off (output enabled) on Autovernier mode off on Autovernier start most significant digit up second significant digit up least significant digit up most significant digit down second significant digit down least significant digit down Execute Self-Test	 D0 D1 A0 A1 MU SU LU MD SD LD EST		HPL wrt 716, "OFS 120 MV, A1, LU"	BASIC OUTPUT 716; "OFS 120 MV, A1, LU" offset is incremented in 1mV steps with offset start value 120 mV
HP-IB Universal Commands Device Clear (DCL) Selected Device Clear (SDC) Group Execute Trigger (GET)		Loads standard parameter set stored in 8116A ROM's. 8116A does not remain in remote mode e.g. CLEAR 7 Loads standard parameter set stored in 8116A ROM's. 8116A remains in remote mode. When the 8116A is in trigger, external sweep mode, this message initiates a single cycle, burst or sweep respectively.	HPL clr 7 clr 716 trg 716	BASIC CLEAR 7 CLEAR 716 TRIGGER 716

- NOTES:
1. Lower case letters can replace any or all of the ASCII capitals.

2. When programming a parameter for which delimiters are given, the parameter string must be terminated with a delimiter e.g. wrt 716, "BUR 17 #".

↑

3. The Autovernier function MUST be enabled BEFORE incrementing/decrementing of any digit can be achieved. Without "A1" appearing in the program string the Autovernier digit commands cannot be executed.

Table 3—4. Mode/Parameter Messages (Talker Function)

Message	ASCII Mnemonics	Sample Statements	
Current Parameter Setting	CST	HPL (HP 9826) dim A\$ [89] or [161] wrt 716, "CST" red 716, A\$	BASIC (HP 85) DIM A\$ [89] or [161] OUTPUT 716;"CST" ENTER 716; A\$
Interrogate Parameter	IERR IFRQ IDTY IWID IHIL ILOL IAMP IOFS IBUR IRPT ISTA ISTP IMRK ISWT	dim B\$ [12] wrt 716, "IFRQ" red 716, B\$	DIM B\$ [12] OUTPUT 716;"IFRQ" ENTER 716; B\$
Status Byte (Serial Poll Enable/ Serial Poll Disable)		rds (716) → A	A = SPOLL (716)

3—71 Error Reporting

3—72 In general, whenever a program attempts to put the 8116A into an error condition, the 8116A responds by making a Service request i.e. set SRQ line true. Under these circumstances, the system controller will address the 8116A as talker using a serial poll command (SPE), the 8116A then responding by putting an error message on the data bus. This message consists of a single 8-bit byte in which SRQ bit 7 is set true ('1') and bits 1 to 3 comprise an error code. The contents of this byte are shown in Table 3—5.

3—73 As can be seen from Table 3—5, bits 1 to 3 are each allocated to an error type. i.e. TIMING, PROGRAMMING and SYNTAX. In each case the bit is set to '1' for error indication.

3—74 Should a more detailed description of the error be required (e.g. duty cycle error or width error when TIMING ERROR is indicated by the status byte), this can be done via the 'interrogate error' (IERR) command. Table 3—6 and 3—7 list the 8116A responses to the IERR command for TIMING and PROGRAMMING errors respectively.

3—75 Service Request. Bit 7 of the HP-IB Status Byte is usually set in conjunction with any of bits 1—4

(error indicators). However, in the case of the TIMING ERROR indication (bit 1), the 'Service Request' message can be suppressed via the command "SR 1"

e.g. (HPL) wrt 716, "SR 1"
(BASIC) OUTPUT 716; "SR 1"

Note: In the permanently stored mode/parameter settings in the 8116A's ROM's, 'SR' is set to '0'. Should these settings be called up as current settings, the service request function can be re-activated for timing errors by programming 'SR' to '0'

e.g. (HPL) wrt 716, "SR0"
(BASIC) OUTPUT 716; "SR0"

3—76 In the event of a FRQ or DTY correction error, SRQ will be displayed until the error has been interrogated by SPOLL. If the current data, for example, includes "FRQ 20 MHZ, W4", and new program data includes "DTY 50 %, W3", SRQ will become active until interrogated, at which time it will be withdrawn. Note that the new DTY value is displayed as 50 % in this case. The reason for this is that at 20 MHz, Duty Cycle selection is not available in Pulse mode. Note also that an "IERR" command will NOT clear SRQ in the event of a DTY or FRQ correction error.

Table 3–5. HP-IB Status Byte

HP-IB Status Byte								Sample Statements	
								HPL (HP 9826)	BASIC (HP 85)
Bit 8 (DIO 8)	Bit 7 (DIO 7)	Bit 6 (DIO 6)	Bit 5 (DIO 5)	Bit 4 (DIO 4)	Bit 3 (DIO 3)	Bit 2 (DIO 2)	Bit 1 (DIO 1)	rds (716) → A	A = SPOLL (716)
								"1" = TIMING ERROR (Causes SRQ)	
								"1" = PROGRAMMING ERROR (Causes SRQ)	
								"1" = SYNTAX ERROR (Causes SRQ)	
								Allocated for error detection during self-test routine — see para 3–60. "1" = SYSTEM FAILURE (Causes SRQ)	
								"1" = AUTOVERNIER IN PROCESS (no SRQ)	
								"1" = SWEEP IN PROCESS (no SRQ)	
								"1" = SERVICE REQUEST	
								"1" = BUFFER NOT EMPTY	

e.g. 0 1 0 0 0 1 0 0 (68 decimal) indicates SYNTAX ERROR

Table 3–6. Timing Error Messages (Response to interrogate error statement 'IERR')

ASCII String	Comments
WAVEFORM ERROR (15 characters)	1. This message is sent when any of the following conditions are not observed: a) In PWM control mode, pulse waveform must be selected. b) In E.WID mode, pulse waveform must be selected. c) With E.WID mode and pulse waveform selected, the only permissible control mode is AM. d) In I.BUR mode, pulse waveform is not allowed. Table 3–1 provides a complete overview of permissible mode/waveform combinations. 2. The 8116A output remains unchanged during the error condition, and front panel LED's blink to indicate the erroneous settings. 3. SRQ cannot be suppressed for this error (see 'Service Request' description).
DUTY C. ERROR (14 characters)	1. This message is sent to indicate 'duty cycle error' when either of the following conditions are not observed: a) In frequency range 1 MHz to 9.99 MHz, duty cycle limits are 20 % to 80 %. b) For frequencies ≥ 10 MHz, duty cycle must be set to 50 %. 2. The erroneous duty cycle setting is not stored in the 8116A memory, and the output remains unchanged. 3. SRQ cannot be suppressed for this error — see 'Service Request' description.

Table 3—6. Timing Error Messages (cont'd)

WIDTH ERROR (12 characters)	1. This message is sent when the width and frequency settings are incompatible. 2. 8116A hardware detects this error condition which causes the output to change. 3. SRQ can be suppressed for this error via the HP-IB message "SR1". In this case, the first bit of the HP-IB status byte is still set to '1' during error condition. "SR1" is the 8116A's default value.
TIMING ERROR (13 characters) (OPT 001 ONLY)	1. This message is sent in I.BUR mode to indicate timing error when: $\text{BUR} \times 1/\text{FRQ} > \text{RPT}$ where BUR = Burst number FRQ = 8116A frequency setting RPT = Burst repetition time 2. 8116A hardware detects this error condition which causes the output to change. 3. SRQ can be suppressed for this error via the HP-IB message "SR1". In this case, the first bit of the HP-IB status byte is still set to '1' during error condition. "SR1" is the 8116A's default value.
NOTE: The 8116A can output more than one error message in response to a single 'IERR' command. e.g. "WAVEFORM ERROR WIDTH ERROR". When multiple errors are suspected, be sure to dimension enough memory space to accommodate the possible character strings.	

Table 3—7. Programming Error Messages (Response to interrogate error statement 'IERR')

ASCII String	Comments
HANDLING ERROR (15 characters)	1. A handling error occurs when: a) User attempts to select Autovernier operation ("A1") when the 8116A is not in NORM ("M1") mode. b) User attempts to exit NORM mode (e.g. program "M2" for TRIG mode) with Autovernier operation selected. The 8116A output changes to correspond to the new mode. c) User attempts to program a parameter value outside the specification limits. e.g. "FRQ 60 MHZ". The 8116A output and display remain unchanged during this error condition. NOTE: Display overflows are NOT indicated.
LEVEL ERROR (12 characters)	1. This message is sent when either of the following conditions are not observed: a) For amplitudes ≥ 100 mV, the HIL/LOL voltage window is ± 8.00 V. b) For amplitudes ≤ 100 mV, the HIL/LOL voltage window is ± 800 mV. Error detection is determined via the following formula: $\text{HIL} = \text{OFS} + 1/2 \text{ AMP}$ $\text{LOL} = \text{OFS} - 1/2 \text{ AMP}$ 2. The 8116A output remains unchanged during the error condition. 3. The programmed level is outside the specification limits. e.g. "HIL 20 V".
LIMIT ERROR (12 characters)	1. Conditions are described for 'LEVEL ERROR' except that the HIL/LOL window is determined by the currently active levels when LIMIT operation is selected.
NOTE: The 8116A can output more than one error message in response to a single 'IERR' command e.g. "HANDLING ERROR LEVEL ERROR". When multiple errors are suspected, be sure to dimension enough memory space to accommodate the possible character strings.	

3-77 Universal HP-IB Commands

3-78 The 8116A will respond to the universal commands listed in Table 3-8, which are sent in the command modes (ATN true).

Table 3-8. HP-IB Universal Commands

Mnemonic	Command	ASCII Code
DCL	Device Clear	DC4
LLO	Local Lockout	DC1
MLA	My Listen Address	(selectable)
MTA	My Talk Address	(selectable)
SPD	Serial Poll Disable	EM
SPE	Serial Poll Enable	CAN
UNL	Unlisten	?
UNT	Untalk	—
GET	Group Execute Trigger	BS
GTL	Go to Local	SOH
SDC	Selected Device Clear	EOT

3-79 Local, Remote and Local Lockout

3-80 Local Capability. In local mode, the 8116A can communicate on the bus by sending a Status Byte indicating 'autovernier in process' or 'sweep in process', as well as responding to the Remote Message.

3-81 Remote Capability. In remote mode, the 8116A's front panel controls are disabled except the LINE switch, LCL key and LEVEL adjust. When addressed to listen, the 8116A will respond to the following bus messages: Data, Trigger, Clear, Remote, Local, Local Lockout, Clear Lockout/Set Local and Abort. When addressed to talk, the 8116A will send one of the following messages: Data, Require Service, or Status Byte.

3-82 The RMT LED is on when the 8116A is in remote mode. The ADS LED is on when the 8116A is currently addressed to talk or listen. The 8116A front panel digital display shows the value of the last programmed parameter.

3-83 Local-to-Remote Change. The 8116A switches to remote upon receipt of the two part Remote Message. The two parts are:

Remote Enable (REN)

Addressed to Listen or Talk (MLS or MTA)

The 8116A's output signal and all control settings remain unchanged with the local-to-remote transition.

3-84 Remote-to-Local Change. The 8116A returns to local control upon receipt of the Local or Clear Lockout/Set Local message. It can also be set to local by pressing the front panel LCL key (assuming that local lockout is not in effect). The output signal and all control settings remain unchanged with the remote-to-local transition.

3-84 Local Lockout. When a data transmission is interrupted, which can happen by returning the 8116A to local with the front panel LCL key, the data could be lost. This would leave the 8116A in an unknown state. To prevent this, a local lockout is recommended to disable the LCL key. Local lockout remains in effect until the 8116A is returned to the local state by either turning the LINE switch off/on or by programming the Local Message.

Table 3-9. Code Assignments (ASCII) for the 8116A

APPLIES ONLY IN COMMAND MODE (ATN TRUE)

THESE CHARACTERS CAUSE SRQ

THESE CHARACTERS ARE IGNORED

DATA MODE
(ATN FALSE)

SAME INTERPRETATION

SAME INTERPRETATION

HP-IB DATA LINES					7	6	5	0	0	0	0	0	1	1	1	1	1
4	3	2	1	0													
0	0	0	0	0	NUL			DLE		SP		0		@		P	
0	0	0	1	1	SOH	GTL		DC1	LLO	!		1		A		Q	
0	0	1	0	2	STX			DC2		"		2		B		R	
0	0	1	1	3	ETX			DC3		#		3		C		S	
0	1	0	0	4	EOT	SDC		DC4	DCL	\$		4		D		T	
0	1	0	1	5	ENQ			NAK		%		5		E		U	
0	1	1	0	6	ACK			SYN		&		6		F		V	
0	1	1	1	7	BEL			ETB		'		7		G		W	
1	0	0	0	8	BS	GET		CAN	SPE	(		8		H		X	
1	0	0	1	9	HT			EM	SPD	)		9		I		Y	
1	0	1	0	10	LF			SUB		*		:		J		Z	
1	0	1	1	11	VT			ESC		+		:		K		[	
1	1	0	0	12	FF			FS		,		<		L		\	
1	1	0	1	13	CR			GS		-		=		M		]	
1	1	1	0	14	SO			RS		.		>		N		^	
1	1	1	1	15	SI			US		/		?	UNL	O		_	UNT
																oo	DEL

SECTION IV

PERFORMANCE TESTS

4-1 INTRODUCTION

4-2 The procedures in this section test the electrical performance of the instrument using the specifications of Table 1-2 as performance standards. All tests can be performed without access to the interior of the instrument.

4-3 EQUIPMENT REQUIRED

4-4 Equipment required for the performance tests is listed in Table 1-1, Recommended Test Equipment. Any equipment that satisfies the critical specifications given in the table may be substituted for the recommended model(s).

4-5 TEST RECORD

4-6 Results of the performance tests may be tabulated on the Test Record at the end of the test procedures. The Test Record lists all of the tested specifications and their acceptable limits. Test results recorded at incoming inspection

can be used for comparison in periodic maintenance, troubleshooting, and after repairs or adjustments.

4-7 PERFORMANCE TESTS

4-8 The performance tests given in this section are suitable for incoming inspection, troubleshooting, or preventive maintenance. During any performance test, all shields and connecting hardware must be in place. The tests are designed to verify the published instrument specifications, perform the tests in the order given and record the data on the Test Record at the end of the test procedures.

4-9 Each test is arranged so that the specification is written as it appears in Table 1-2. Next, when necessary, a description of the test and any special instructions or problem areas are included. Each test that requires test equipment has a setup drawing and a list of the required equipment. The initial steps of each procedure give control settings required for that particular test.

PERFORMANCE TESTS

4-10 FREQUENCY

SPECIFICATION

1.00 mHz to 50 MHz

(1 mHz to 999 kHz for 10 % and 90 % duty cycle)

(1 mHz to 9,99 MHz for 20 % and 80 % duty cycle)

Accuracy in Norm input mode:

% of setting	Pulse mode or 50 % duty cycle	≠ 50 % duty cycle
1 mHz to 99,9 kHz	± 3 %	± 3 %
100 kHz to 9,99 MHz	± 5 %	± 10 %
10 MHz to 50 MHz	± 5 %	—

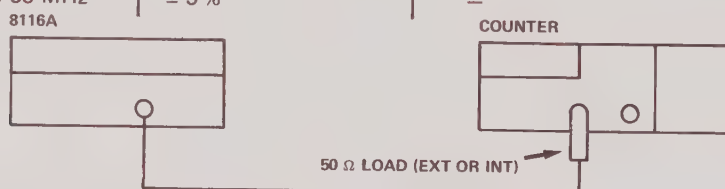


Figure 4-1. Test Setup for Frequency, Burst and Sweep

EQUIPMENT

Counter

Cable Assembly BNC (61 cm)

Feedthrough Termination 50 Ω (if necessary)

PROCEDURE

1. Connect equipment as shown in Figure 4-1.

2. Set 8116A as follows:

INPUT MODE	.....	NORM
FUNCTION	.....	SQUARE
DUTY CYCLE	.....	50 %
CTRL	.....	OFF
AMPL	.....	1 V
OFFSET	.....	0 V
OUTPUT MODE	.....	NORM

3. Set counter to frequency measurement.

4. Set 8116A frequency and verify counter frequency reading as follows:

8116A setting	Counter reading
50,0 MHz	50.0000 MHz ± 2500 kHz
10,0 MHz	10.0000 MHz ± 500 kHz
10,0 kHz	10.0000 kHz ± 300 Hz
1,0 kHz	1.00000 kHz ± 30 Hz

5. Set 8116A frequency and verify counter period reading as follows:

8116A setting	Counter reading
1.00 Hz	1.00000 s ± 33.3 ms
100 mHz	10.00000 s ± 333 ms

PERFORMANCE TESTS

4-11 PULSE WIDTH (pulse mode)

SPECIFICATION

10 ns to 999 ms
Accuracy $\pm 5\%$ of setting ± 2 ns

EQUIPMENT

- Counter
- Cable Assembly BNC
- Sampling oscilloscope
- Feedthrough Termination (if necessary)

PROCEDURE

- Connect equipment as shown in Figure 4-1.
- Set 8116A as follows:

INPUT MODE NORM
FUNCTION PULSE
CTRL OFF
FRQ 1 MHz
AMP 1 V
OFS 0 V

- Set counter to TI, COMA, CH A +, CH B -, Trig level 0 V.
- Set 8116A width /frequency as shown and verify counter width reading.

FREQUENCY	WIDTH	COUNTER READING
1 MHz	100 ns	93 ns — 107 ns
100 KHz	1 μ s	948 ns — 1052 ns
1 KHz	100 μ s	95 μ s — 105 μ s
10 Hz	1 ms	950 μ s — 1050 μ s
1 Hz	500 ms	475 ms — 525 ms

- Connect the equipment as shown in Figure 4-6.
- Set 8116A as follows:

FRQ 10.0 MHz
WID 8.0 ns
- Set sampling scope such that one cycle fills the display. Verify that width is between 7.5 and 10 ns.

PERFORMANCE TESTS

4-12 BURST (Option 001 only)

SPECIFICATION

A pre-programmed number of output cycles is generated on receipt of an input trigger signal or manual command, min time between bursts: 100 ns. Burst length: 1 to 1999 cycles. Frequency up to 40 MHz.

EQUIPMENT

Counter
Cable Assembly BNC (61 cm)
Feedthrough Termination 50 Ω (if necessary).

PROCEDURE

1. Load Burst number 816 into 8116A.
2. Set 8116A as follows:

INPUT MODE	EXT BURST
FUNCTION	SQUARE
DUTY CYCLE	50 %
CTRL	OFF
FRQ	10 kHz
AMPL	1 V
OFFSET	0 V
BURST	816
OUTPUT MODE	NORM

3. Use Figure 4-1 test setup and set counter to START.
4. Press 8116A's MAN button and verify that counter now displays the set number (816) of output cycles. (5345A reading will be 815, since first pulse arms the counter).

PERFORMANCE TESTS

4-13 AMPLITUDE AND OFFSET

SPECIFICATION

Amplitude and offset are independently variable within the two following level windows.

Level window	$\pm 800\text{ mV}$	$\pm 8.00\text{ V}$
Amplitude range	10.0 mVpp to 99.9 mVpp	100 mVpp to 16.0 Vpp
Ampl. resolution	3 digits	3 digits
Ampl. accuracy*	$\pm 5\%$ (0.45 dB)	$\pm 5\%$ (0.45 dB)
Repeatability	Factor 4 better than accuracy	
Offset range	0 to $\pm 795\text{ mV}$	0 to $\pm 7.95\text{ V}$
Offset resolution	3 digits (best case 100 μV)	3 digits (best case 1 mV)
Offset accuracy	$\pm 1\%$ of setting $\pm 1\%$ of amplitude $\pm 4\text{ mV}$	$\pm 0.5\%$ of setting $\pm 1\%$ of amplitude $\pm 40\text{ mV}$
Repeatability	Factor 4 better than accuracy	

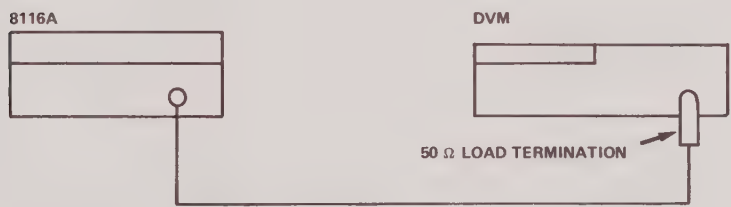


Figure 4-2. Test Setup for Amplitude and Offset

EQUIPMENT

Digital Voltmeter (RMS)
Cable Assembly BNC (1 x 61 cm)
Feedthrough Termination 50 Ω

If total error is $> \pm .5\%$ of nominal, note deviation and take into account during measurement.

PROCEDURE

1. Connect the equipment as shown in Figure 4-2.
2. Set 8116A as follows:

INPUT MODE	.....	NORM
FUNCTION	.....	SINE
DUTY CYCLE	.....	50 %
CTRL	.....	OFF
FRQ	.....	1,0 kHz
OFFSET	.....	0 V
OUTPUT MODE	.....	NORM

PERFORMANCE TESTS

AMPL	FUNCTION	DVM Reading *
8.00 V	Sine W1	2,69 — 2,97 V
	triangle W2	2,19 — 2,43 V
	square W3	3,8 — 4,2 V
3.00 V	Sine	1,008 — 1,114 V
	triangle	0,823 — .909 V
	square	1,425 — 1,575 V
1.00 V	Sine	0,336 — 0,372 V
	triangle	0,275 — 0,303 V
	square	0,475 — 0,525 V
100 mV	Sine	33,6 — 37,1 mV
	triangle	27,4 — 30,3 mV
	square	47,5 — 52,5 mV

3. Set 8116A to NORM mode, Amplitude 100 mV.
4. Using best DVM resolution, measure the dc voltages for the following 8116A settings:

OFFSET	DVM Reading *
7.5 V	7,421 — 7,578 V
5.00 V	4,934 — 5,066 V
3.00 V	2,944 — 3,056 V
1.00 V	0,954 — 1,046 V
100 mV	58 mV— 142 mV

5. Set 8116A to amplitude 10 mV and measure the DC voltages for the following 8116A settings:

OFFSET	DVM Reading *
795 mV	783 — 807 mV
500 mV	491 — 509 mV
100 mV	95 — 105 mV

* last digit rounded

PERFORMANCE TESTS

4-14 SINE CHARACTERISTICS

SPECIFICATION

- Total Harmonic Distortion (THD): < 1 % (–40 dB),
(10 Hz to 50 kHz)
- Harmonic Signals: More than 34 dB below fundamental (50 kHz to 1 MHz).
More than 23 dB below fundamental (1 MHz to 50 MHz, > 20 mVpp to 8 Vpp.)

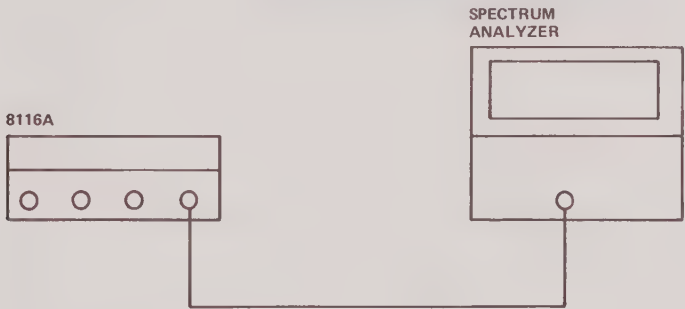


Figure 4-3. Test Setup for Sine Characteristics

EQUIPMENT

- Spectrum analyzer
- Cable assembly BNC (1 x 61 cm)

PROCEDURE

- Connect the equipment as shown in Figure 4-3.
- Set 8116A as follows:

INPUT MODE	.....	NORM
FUNCTION	.....	SINE
DUTY CYCLE	.....	50 %
CTRL	.....	OFF
FRQ	.....	1 kHz
AMPL	.....	8 V
OFFSET	.....	0 V
OUTPUT MODE	.....	NORM
- Tune spectrum analyzer for minimum display amplitude. Adjust gain so that fundamental corresponds to 0 dB.

PERFORMANCE TESTS

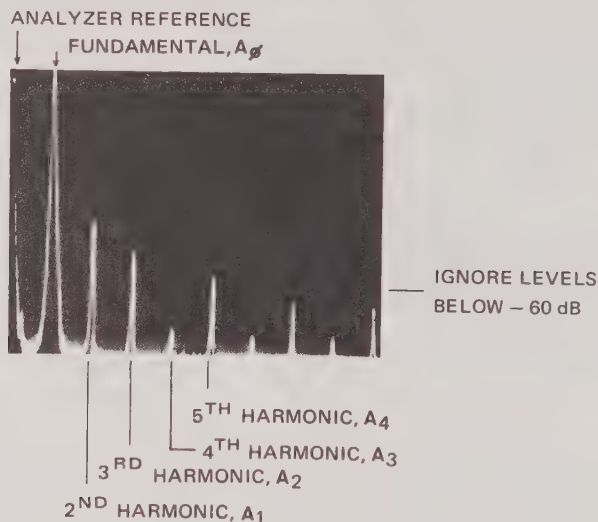


Figure 4-4. Typical Spectrum Analyzer Display at 1 KHz

The value of harmonics may differ between instruments.

4. Verify that $THD < 1\%$

$$THD = \frac{\sqrt{E_1^2 + E_2^2 + E_3^2 + \dots}}{E_0} \cdot 100\%$$

where E_0 = fundamental voltage amplitude and E_1, E_2 etc are the 2nd, 3rd etc harmonic amplitudes.

When the harmonics are expressed in dB the formula becomes:

$$THD = \sqrt{10^{\frac{A_1}{10}} + 10^{\frac{A_2}{10}} + 10^{\frac{A_3}{10}} + \dots} \cdot 100\%$$

where A_1 = first harmonic in dB etc.

5. Set 8116A FRQ to 50 MHz.
6. Tune spectrum analyzer for minimum display amplitude. Adjust gain so that fundamental corresponds to 0 dB. Verify that no harmonics exceed the -23 dB level.

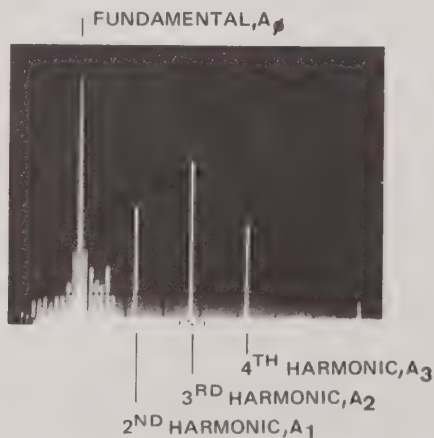


Figure 4-5. Typical Spectrum Analyzer Display at 50 MHz, NORM

The value of harmonics may differ between instruments.

PERFORMANCE TESTS

4-15 PULSE CHARACTERISTICS

SPECIFICATION

- Transition times (10 % to 90 %): < 6 ns
- Preshoot/Overshoot/Ringing: ± 5 %

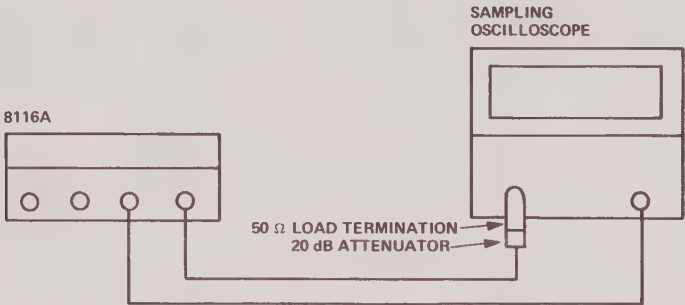


Figure 4-6. Test Setup for Pulse Characteristics

EQUIPMENT

- Sampling oscilloscope
- Cable assembly BNC (2 x 61 cm)
- Feedthrough termination 50 Ω
- Power attenuator 20 dB, 20 W

PROCEDURE

1. Connect the equipment as shown in Figure 4-6.
2. Set the 8116A as follows:

INPUT MODE	NORM
FUNCTION	SQUARE
DUTY CYCLE	50 %
CTRL	OFF
FRQ	1 MHz
AMPL	8 V
OFFSET	0 V
OUTPUT MODE	NORM

3. Set scope so that one cycle fills the display and measure:

- leading edge (risetime) ≤ 6 ns
- trailing edge (risetime) ≤ 6 ns
- preshoot ≤ ± 5 % of amplitude *
- overshoot and ringing ≤ ± 5 % of amplitude *

* note possible sampling error

PERFORMANCE TESTS

4-16 TRIGGER, GATE and E.WIDTH PERFORMANCE

SPECIFICATION

Trig: pos. ext input pulse ≥ 10 ns wide generates one output cycle.

Sensitivity: 500 mVpp

Gate: Ext. signal enables oscillator. First output cycle synchronous with active trigger slope.

Last cycle always completed.

E.Width: External signal will be shaped to determine output pulse width and period. (Pulse mode only).

Max. input: $\pm 20 \text{ V}$

Input impedance: 10 k Ω typical

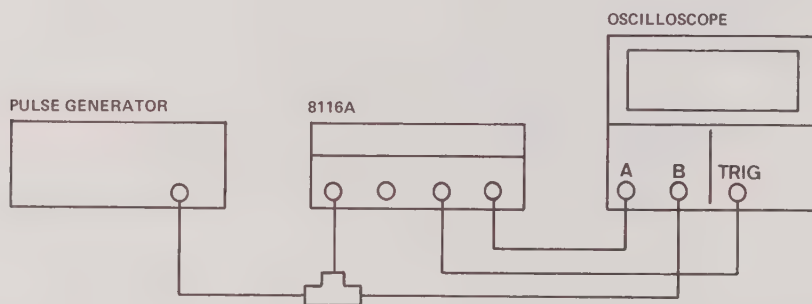


Figure 4–7. Test Setup for Burst Gate and Trigger Performance

EQUIPMENT

Pulse generator

Oscilloscope

Cable assembly (3 x 61 cm, 2 x 30 cm)

BNC Tee,

Feedthrough termination $50\ \Omega$

PROCEDURE

1. Connect the equipment as shown in Figure 4-7.
2. Set the 8116A as follows:

INPUT MODE	TRIG
FUNCTION	SINE
DUTY CYCLE	50 %
CTRL	OFF
FRQ	60 KHz
AMPL	1 V
OFFSET	0 V
OUTPUT MODE	NORM
EXT INPUT	≠

PERFORMANCE TESTS

3. Set ext. function generator for output pulse approx 50 μ s wide, rep. rate 10 kHz, baseline zero or more negative, pulse top + 1 V. Adjust 8116A trigger input level for correct trigger. Verify that each trigger pulse generator one complete output cycle (Figure 4–8).

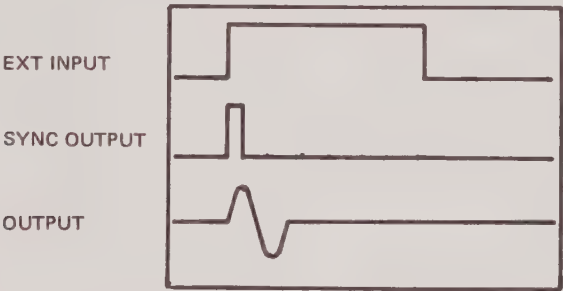


Figure 4–8. Example of correct trigger operation

4. Set 8116A to GATE mode. Verify that each positive gate releases a burst of output cycles and that each cycle is complete (Figure 4–9).

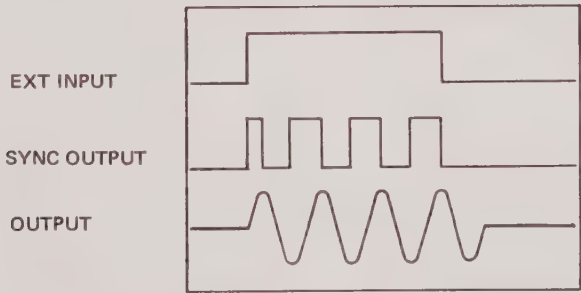


Figure 4–9. Example of correct gate operation

5. Set 8116A waveform to PULSE and mode to E.WIDTH. Verify that each external pulse releases a pulse of same width.

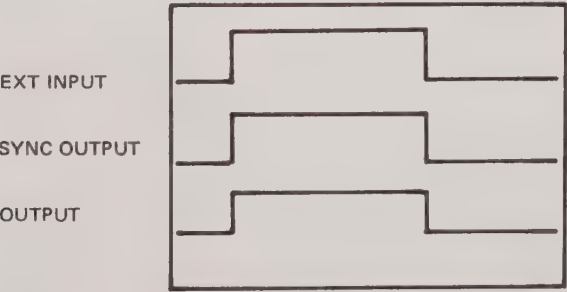


Figure 4–10. Example of correct E.Width operation

PERFORMANCE TESTS

4-17 FM

SPECIFICATION

Output is frequency modulated by an external voltage applied to the CTRL Input, 1 V modulates 1 % deviation.

Deviation: $\pm 5\%$ max

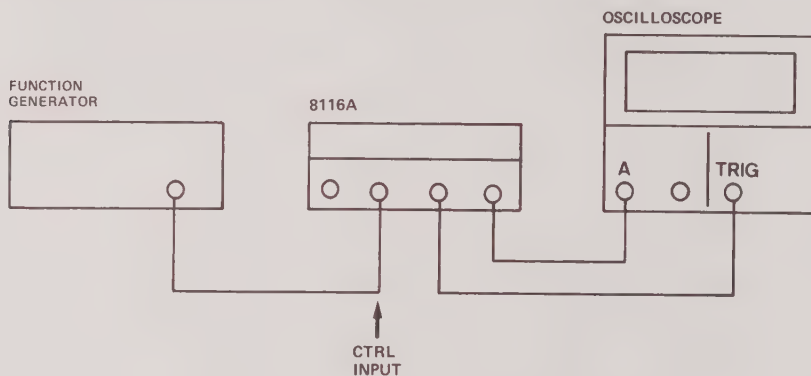


Figure 4-11. Test Setup for FM

EQUIPMENT

Oscillator
Oscilloscope
Cable assembly BNC (3 x 61 cm)

PROCEDURE

1. Connect the equipment as shown in Figure 4-11.
2. Set oscillator to 10 kHz, 2 Vpp
3. Set oscilloscope to 0,1 μ s/div timebase, Magnification X10
4. Set the 8116A as follows:

INPUT MODE	.....	NORM
FUNCTION	.....	SQUARE
DUTY CYCLE	.....	50 %
CTRL	.....	FM
FRQ	.....	1 MHz
AMPL	.....	1 V
OFFSET	.....	0 V
OUTPUT MODE	.....	NORM

5. Check the delayed sweep for a typical jitter of 2 div $\pm 10\%$.

PERFORMANCE TESTS

4-18 AMPLITUDE MODULATOR

SPECIFICATION

Modulating Frequency: dc to 1 MHz (-3 dB).
Input impedance: 10 kΩ typical.
Envelope Distortion: (dc to 50 kHz mod. freq. in Normal mode only.)

Carrier	Modulation	Distortion
≤ 1 MHz	0 to 90 %	< 1 %
> 1 MHz	0 to 30 %	< 3 %

Carrier Frequency Deviation: < 0.01 %, 0 to 30 % modulation.

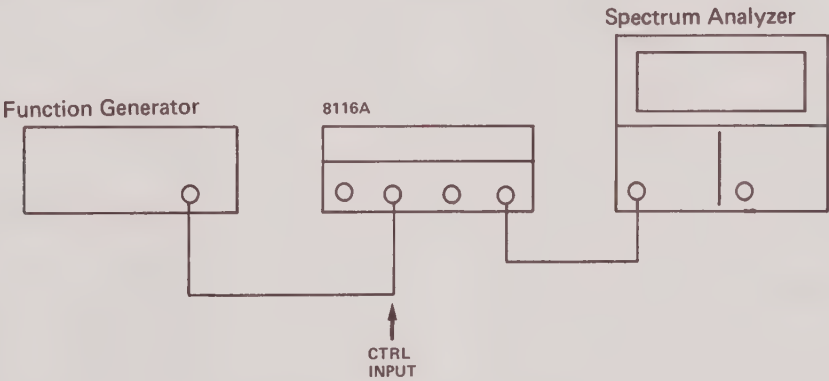


Figure 4-12. Test setup for AM

EQUIPMENT

Function Generator
spectrum analyzer

PROCEDURE

1. Connect the equipment as shown in Figure 4-12.
2. Set the 8116A as follows:

INPUT MODE	NORM
FUNCTION	SINE
DUTY CYCLE	50 %
CTRL	AM
FRQ	10 kHz
AMPL	1 V
OFFSET	0 V
OUTPUT MODE	NORM
3. Set Function Generator to 2 kHz and 4.5 Vpp amplitude, with 0.25 V offset.
4. Adjust the spectrum analyzer to display the 10 kHz carrier and the lower sideband frequency down to the 2 kHz modulating frequency. All harmonics should be at least 42 dB lower than the modulation sidebands.

PERFORMANCE TESTS

4-19 PULSE WIDTH MODULATION

SPECIFICATION

Pulse Width ratio: 10:1 max.
Sensitivity: $\pm 6,5V$ typically for ratio 1:10
Pulse Width ranges: 10 ns to 1 s in eight non-overlapping decade ranges.

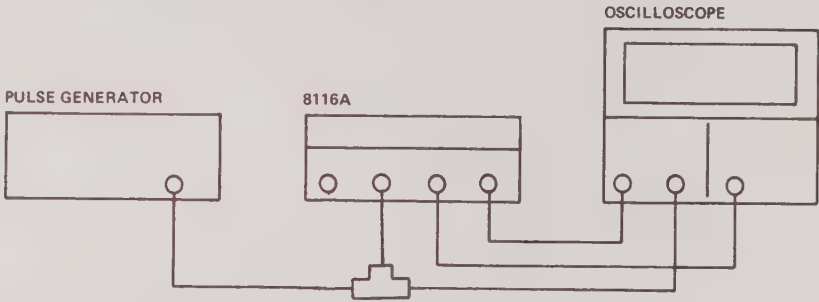


Figure 4-13. Test setup for PWM

EQUIPMENT

- Realtime scope
- Pulse Generator
- Cable Assembly BNC (4x61 cm)
- BNC Tee

PROCEDURE

- Connect equipment as shown in Figure 4-13.
- Set 8116A as follows:

INPUT MODE	NORM
FUNCTION	PULSE
CTRL	PWM
HIL	1.0 V
LOL	0.0 V
OUTPUT MODE	NORM

- Set the Pulse Generator as follows:

FUNCTION	SINE
FREQUENCY	1 Hz
AMPLITUDE	13.0 Vpp
OFFSET	0.0 V

- Select the settings shown for each test in the following Table. Verify that the 8116A Pulse Width varies with the amplitude of the signal applied to the CTRL INPUT within the given limits.

NOTE: When a width value is selected, the 8116A displays the value corresponding to a 0 V CTRL input WITHIN THE DECADE RANGE OF THE SELECTED WIDTH VALUE.
e.g. Decade = 100 ns to 1.0 us, display reads 550 ns

8116A WIDTH			SCOPE	
FREQUENCY	DECADE RANGE	DISPLAY	MIN. WID	MAX. WID
1 MHz	10 ns – 100 ns	55 ns	10 ns	100 ns
100KHz	100 ns – 1.0 μ s	550 ns	100 ns	1.0 μ s
100 Hz	100 μ s – 1.0ms	550 μ s	100 μ s	1.0ms

PERFORMANCE TESTS

4–20 DUTY CYCLE (sine, triangle, square)

SPECIFICATION

- Range: 10 % to 90 % (1 mHz to 999 kHz)
20 % to 80 % (1 MHz to 9.99 MHz)
Accuracy: ± 0.5 digits (1 mHz to 999 kHz)
± 3.0 digits (1 MHz to 9.99 MHz)

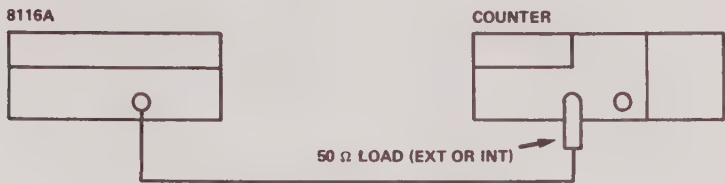


Figure 4–14. Test setup for Duty Cycle

EQUIPMENT

- Counter
- Cable Assembly BNC (1 x 61 cm)

PROCEDURE

- Connect the equipment as shown in Figure 4–14.
- Set 8116A as follows:

INPUT MODE	.....	NORM
FUNCTION	.....	SQUARE
CTRL	.....	OFF
AMP	.....	1.0 V
OFS	.....	0.0 V
OUTPUT MODE	.....	NORM
- Set the counter to DTY CY A. Set 8116A duty cycle / frequency as shown and verify counter duty cycle readings.

FREQUENCY	DUTY CYCLE	COUNTER READING
1 Hz	10 %	9.5 % to 10.5 %
	50 %	49.5 % to 50.5 %
	90 %	89.5 % to 90.5 %
1 kHz	10 %	9.5 % to 10.5 %
	50 %	49.5 % to 50.5 %
	90 %	89.5 % to 90.5 %
9.99 MHz	20 %	17.0 % to 23.0 %
	50 %	47.0 % to 53.0 %
	80 %	77.0 % to 83.0 %

PERFORMANCE TESTS

4-21 SWEEP (Opt. 001 only)

SPECIFICATION

Logarithmic sweep for all waveforms up to full range (1 mHz to 50 MHz) between selected start and stop frequency. Sweep time per decade selectable in 1-2-5 sequence between 10 ms and 500 s.

EQUIPMENT

- Realtime scope
- Pulse Generator
- Cable Assembly BNC (3 x 61 cm)

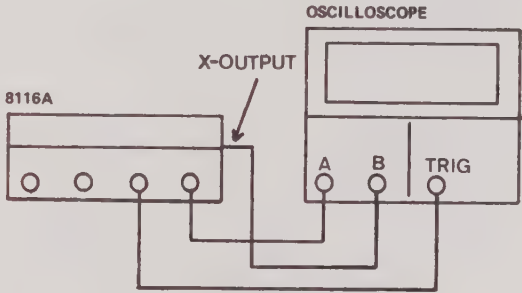


Figure 4-15. Test setup for SWEEP

PROCEDURE

1. Connect equipment as shown in Figure 4-15.
2. Set the 8116A as follows:

INPUT MODE	.....	E.SWP
FUNCTION	.....	SINE
CTRL	.....	OFF
STA	.....	10 kHz
STP	.....	10 MHz
SWT	.....	2 s/decade
MRK	.....	1.0 MHz
AMPLITUDE	.....	1.0 V
OFFSET	.....	0.0 V
OUTPUT MODE	.....	NORM

3. Set the channel B vertical scale to 1.0 V/division and the scope timebase to 50 us/division. Verify that the frequency of the displayed sinewave on Channel A is 10 kHz.
4. Press the MAN pushbutton on the 8116A frontpanel and confirm that
 - a) the 8116A displays IP
 - b) the frequency of the displayed signal increases
 - c) the level of the X-OUTPUT gradually rises from 0 V to 4.5 V during the sweep time (6 seconds).
5. Adjust the scope timebase to 50 ns/division and verify that the frequency of the displayed sinewave on channel A is 10 MHz.
6. Disconnect the X-OUTPUT of the 8116A from the scope and connect the MARKER OUTPUT in its place. Press MAN to return to the start frequency. Press MAN again to begin the sweep, and note that the MARKER OUTPUT switches instantaneously when the marker frequency (1 MHz) has been reached (4 seconds after the sweep was initiated).
7. Select I.SWP at the 8116A frontpanel. Verify that the internal sweep is running, and that the start, stop and marker frequencies, sweep time/decade and X-OUTPUT are identical to the previously set values.

PERFORMANCE TESTS

4-22 DC VOLTAGE (all waveform keys deactivated)

SPECIFICATION

Range: 0 V to ± 7.95 V
Resolution: 3 digits (best case 1 mV)
Accuracy: $\pm 0.5\%$ of setting ± 20 mV

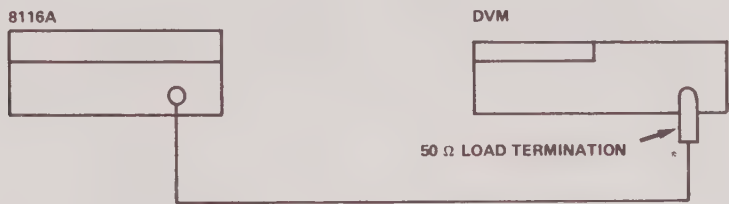


Figure 4-16. Test setup for DC Voltage

EQUIPMENT

Digital Voltmeter
Cable Assembly BNC (1 x 61 cm)

PROCEDURE

- 1. Connect the equipment as shown in Figure 4-16.
- 2. Set 8116A as follows:

INPUT MODE	.....	NORM
FUNCTION	.....	OFF
CTRL	.....	OFF
OUTPUT MODE	.....	NORM

- 3. Set 8116A AMP and OFS values as shown and verify DVM reading.

AMP	OFS	DVM READING
+100 mV	+7.95 V	+7.890 V – +8.010 V
+100 mV	+5.00 V	+4.955 V – +5.045 V
+100 mV	+2.00 V	+1.970 V – +2.030 V
+100 mV	0.00 V	–0.020 V – +0.020 V
+100 mV	–2.00 V	–2.030 V – –1.970 V
+100 mV	–5.00 V	–5.045 V – –4.955 V
+100 mV	–7.95 V	–8.010 V – –7.890 V

PERFORMANCE TESTS

4-23 MAN, 1 CYCLE, LIMIT, COMPLEMENT and DISABLE OPERATION

FUNCTION AND CAPABILITY

MAN: Simulates external input.

1 CYCLE: (Opt. 001 only). Provides a single output period in EXT BURST mode.

AUTO: In NORM mode, all parameters can be automatically incremented or decremented with selectable resolution. Pushing the AUTO button activates the AUTO vernier, which can then be started with the selected vernier key. AUTO vernier stop is accomplished by an external trigger input or pushing AUTO.

LIMIT: Maximum high and low levels into 50 Ohm can be limited to protect the device under test. Pushing the LIMIT key will set the limits to the actual levels, which then cannot be exceeded as long as the mode is active.

COMPL: Switch-selectable normal/complement output.

DISABLE: Relay disconnects all output circuitry.

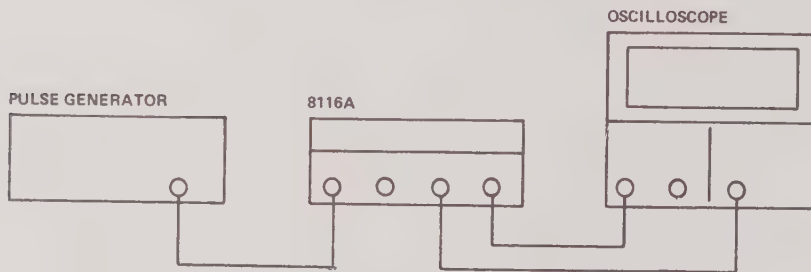


Figure 4-17. Test setup

EQUIPMENT

Realtime scope
Counter
Pulse Generator
Cable Assembly BNC (3 x 61 cm)

PROCEDURE

1. Connect equipment as shown in Figure 4-17.
2. Set 8116A as follows:

INPUT MODE	.....	NORM
FUNCTION	.....	SQUARE
CTRL	.....	OFF
FREQUENCY	.....	1 kHz
HIL	.....	1.0 V
LOL	.....	0.0 V
OUTPUT MODE	.....	NORM
DUTY CYCLE	.....	10 %
TRIG SLOPE	.....	NOT SELECTED

NOTE: The Autovernier acts upon the LAST selected parameter.

PERFORMANCE TESTS

3. Adjust the scope timebase to 0.2 ms/div and select AUTO at the 8116A frontpanel. Press the upper section of the right hand VERNIER key and verify that the duty cycle of the 8116A output is incremented to 90 %. Press the lower section of the left-hand VERNIER key and verify that the duty cycle decremented to 10 %. Deselect the AUTO pushbutton. Ensure that no Ext. Input Slope is selected.
4. Press the COMPL pushbutton and verify that the 8116A output becomes inverted. Deselect the COMPL pushbutton.
5. Select DISABLE at the 8116A frontpanel and confirm that the output is withdrawn.

6. Make the following adjustments to the 8116A frontpanel settings:
OPT. 001

INPUT MODE	EXT BURST
FUNCTION	PULSE
CTRL	OFF
BUR	123
FREQUENCY	100 Hz
WIDTH	5 μ s
AMP	4.0 V
OFS	0.0 V
OUTPUT MODE	LIMIT

7. Disconnect the scope and connect the counter in its place. Set the Counter to TOT A. Reset the counter and enable the GATE. Press MAN. Verify that the counter reads 123. Note that 5345A counter will read 122, since the first pulse arms the counter.
8. Deselect the EXT INPUT trigger and reset the counter. Press the 1 CYCLE key on the 8116A frontpanel. Confirm that the counter reading is 124. Reset the counter and press the MAN key on the 8116A frontpanel. Verify that the new counter reading is 123.
9. Select the AMP parameter on the 8116A frontpanel. Verify that pressing the VERNIER keys will not increase the amplitude of +4.0 V set previously. Similarly, when OFS is selected, verify that the previously set level of 0.0 V cannot be made more negative by action of the VERNIER keys.

PERFORMANCE TESTS

4-24 HP-IB CAPABILITY

EQUIPMENT

System Controller
 Realtime scope
 HP-IB Cable Assembly
 Cable Assembly BNC (1 x 61 cm)

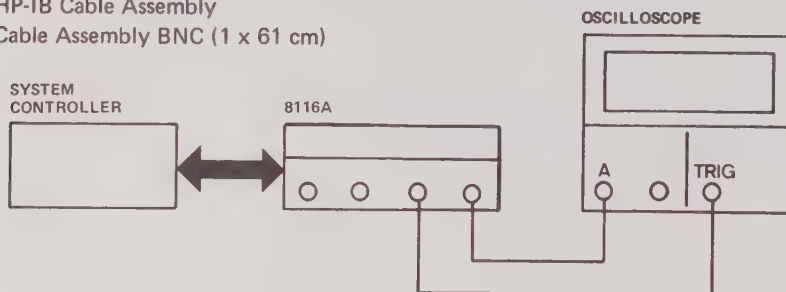


Figure 4-18. Test setup for HP-IB capability

PROCEDURE

1. Connect equipment as shown in Figure 4-18.
2. Type the following instructions to the 8116A via the system controller:


```
REMOTE 716
CLEAR 716
DIM A$ [161]
OUTPUT 716; "CST"
ENTER 716; A$
PRINT A$
```
3. Verify that the controller output is as follows:


```
M1,CT0,T1,W1,H0,A0,L0,C0,D1,BUR
0001 #,RPT 100 MS,STA 1.00 KHZ,
STP 100 KHZ,SWT 50.0 MS,MRK 1.00 KHZ,
FRQ 1.00 KHZ, DTY 50 %, WID 500 US,
HIL +0.50 V, LOL -0.5 V
```
4. Type the following instruction to the 8116A via the controller:


```
OUTPUT 716; "FRQ 10 KHZ, DTY 10 %,
W3, HIL 1.5 V"DO"
DIM B$ [161]
OUTPUT 716; "CST"
ENTER 716; B$
PRINT B$
```
5. Verify that the controller printer output data matches the data previously output in step 3, except for the following changes:


```
FRQ 10.0 KHZ
DTY 10 %
HIL 1.50 V
W3
DO
```
5. Check the scope display to confirm that the 8116A output waveform has the following parameters:


```
SQUARE, Frequency 10 kHz, Duty Cycle 10 %,
High Level 1.50 V, Low Level -0.50 V.
```

PERFORMANCE TESTS

Table 4--1. Performance Test Record

Hewlett-Packard Company Model 8116A/8116A Option 001 Programmable Signal Source Serial No. _____					Tested By _____ Date _____				
Para. No.	Test Description		Results						
			Min	Actual	Max				
4-10	Frequency								
	50.0 MHz		47,5 MHz	_____	52,5 MHz				
	10.0 MHz		9,5 MHz	_____	10,5 MHz				
	10.0 kHz		9,7 kHz	_____	10,3 kHz				
	1.00 kHz		0,97 kHz	_____	1,03 kHz				
	1.00 Hz		0,967 ms	_____	1,033 ms				
	100 mHz		9,66 ms	_____	10,33 ms				
4-11	Pulse Width								
	100 ns		93 ns	_____	107 ns				
	1 μ s		948 ns	_____	1052 ns				
	100 μ s		95 μ s	_____	105 μ s				
	1 ms		950 μ s	_____	1050 μ s				
	500 ms		475 ms	_____	525 ms				
	8 ns		7.5 ns	_____	10 ns				
4-12	Burst (Option 001) only Number of actual output cycles same as set burst length ?			yes/no					
4-13	Amplitude and Offset								
	AMPL	FUNCTION							
	8.00 V	sine *	2.69 V	_____	2.97 V				
		triangle *	2.19 V	_____	2.43 V				
		square *	3.8 V	_____	4.2 V				
	3.00 V	sine *	1.008 V	_____	1.114 V				
		triangle *	0.823 V	_____	0.909 V				
		square *	1.425 V	_____	1.575 V				
	1.00 V	sine *	0.336 V	_____	0.372 V				
		triangle *	0.275 V	_____	0.303 V				
		square *	0.475 V	_____	0.525 V				
	100 mV	sine *	33.6 mV	_____	37.1 mV				
		triangle *	27.4 mV	_____	30.3 mV				
		square *	47.5 mV	_____	52.5 mV				

PERFORMANCE TESTS

Para No.	Test Description	Results		
		Min	Actual	Max
4-13	OFFSET			
	7.5 V	7,421 V	_____	7,578 V
	5.00 V	4,934 V	_____	5,066 V
	3.00 V	2,944 V	_____	3,056 V
	1.00 V	0,954 V	_____	1,046 V
	100 mV	58 mV	_____	142 mV
4-14	Sine Characteristics (Harmonic level)			
	FRQ = 1 kHz (2 nd harmonic)		_____	-42 dB
	FRQ = 1 kHz (3 rd harmonic)		_____	-47 dB
	FRQ = 1 MHz (THD)		_____	1 %
	FRQ = 50 MHz (worst harmonic)		_____	-23 dB
4-15	Pulse Characteristics			
	Leading edge		_____	≤ 6 ns
	Trailing edge		_____	≤ 6 ns
	Preshoot	≤ -5 %	_____	≤ +5 %
	Overshoot and ringing	≤ -5 %	_____	≤ +5 %
4-16	Trigger, Gate, E.Width			
	Positive trigger releases one complete output cycle ?		yes/no	
	Positive gate releases a burst of output cycles, fast cycle complete ?		yes/no	
	Positive pulse releases a pulse of same width ?		yes/no	
4-17	FM Mode Jitter, FM on		_____	
4-18	Amplitude Modulator (worst harmonic)		_____	-42 dB
4-19	Pulse Width Modulator			
	10 ns → 100 ns		yes/no	
	100 μs → 1.0 ms		yes/no	
	100 ms → 1.0 s		yes/no	

PERFORMANCE TESTS

Para. No.	Test Description	Results		
		Min	Actual	Max
4-20	DUTY CYCLE			
	FRQ DTY CY			
	10 %	9.5 %	_____	10.5 %
	1 Hz 50 %	49.5 %	_____	50.5 %
	90 %	89.5 %	_____	90.5 %
	10 %	9.5 %	_____	10.5 %
	1 KHz 50 %	49.5 %	_____	50.5 %
	90 %	89.5 %	_____	90.5 %
	20 %	17.0 %	_____	23.0 %
	9.99 MHz 50 %	47.0 %	_____	53.0 %
	80 %	77.0 %	_____	83.0 %
4-21	SWEEP (Opt. 001 only) frequency 10 kHz 'IP' displayed frequency increases X-OUTPUT 0 V → 4.5 V in 6 seconds 10 MHz Verify 3, 4 and 5 MARKER OUTPUT functional ? Internal sweep running ? STA, STP, SWT, MRK and X-OUTPUT functional ?		yes/no yes/no yes/no yes/no yes/no yes/no yes/no yes/no yes/no	
4-22	D.C. VOLTAGE	+7.890 V +4.955 V +1.970 V -0.020 V -2.030 V -5.045 V -8.010 V	_____ _____ _____ _____ _____ _____ _____	+8.010 V +5.045 V +2.030 V +0.020 V -1.970 V -4.955 V -7.890 V
4-23	MAN, 1 CYCLE, LIMIT, COMPL and DISABLE AUTOVERNIER functional ? COMPL functional ? DISABLE functional ? MAN Reading 123 ?* 1 CYCLE Reading 124 ?* LIMIT functional ?		yes/no yes/no yes/no yes/no yes/no yes/no	
4-24	HP-IB functional ?		yes/no	

* (5345A reading will be 122/123, since the first pulse arms the counter)

Related Paragraph	Component	Range of values	Description
Overshoot/ Transition Times	A1 C530	jumper or 1 pF	jumper increases overshoot
	A1 C525	1.5 pF – 6.8 pF	decreasing C 525 value increases transition times
Voltage Controlled Oscillator	A1 R220/R223	1.5 k – 4.02 k	increasing R220/223 values increases amplitude flatness
	A1 R242	1.0 k – 1.3 k	Baseline accuracy in TRIG Mode and startphase 0°
Width	A1 R309	1 Ohm – 100 Ohm	increasing R309 value decreases min. Width (< 10 ns)
	A1 R310	1 k, 2k or open	change, if min. and max. Widths are not adjustable
	A1 R157	4.5 k – 5.56 k	increasing R157 value decreases Width in PWM Mode
Shaper	A1 R439	7.5 k – open	increasing R439 value increases offset in normal Mode and decreases offset in complement Mode
	A1 R428	10 k – open	decreases 2nd harmonic at 1.00 V amplitude (increasing R428 decreases negative offset)

Table 5-1. * Values

NOTE: All resistors are 0.125 W, $\pm 1\%$

SECTION V

ADJUSTMENT PROCEDURE

5-1 INTRODUCTION

This section describes the adjustments which will return the instrument to peak operating condition after repairs are completed. An adjustment location diagram is given on a fold-out page at the end of this section.

5-2 SAFETY CONSIDERATIONS

Although this instrument has been designed in accordance with international safety standards, this manual contains information, cautions, and warnings which must be followed to ensure safe operation and to retain the instrument in safe condition (see Sections II and III).

WARNING

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnection of the protective earth terminal is likely to make the instrument dangerous. Intentional interruption is prohibited.

Any adjustment, maintenance, or repair of the opened instrument with voltage applied should be avoided as much as possible and, when inevitable, should be carried out only by a skilled person who is aware of the hazard involved.

5-3 EQUIPMENT REQUIRED

The test equipment required for the adjustment procedure is listed in Table 1-1, Recommended Test Equipment. The critical specifications of substitute test instruments must meet or exceed the standards listed in the table if the instrument is to meet the standards set forth in Table 1-2, Specifications.

5-4 ADJUSTMENT PROCEDURE

The adjustment procedure is divided into the following sections:

5-6	Power Supplies
5-7	Pre-adjustments
5-8	Overshoot/Transition Times
5-9	Voltage Controlled Oscillator
5-10	Width
5-11	Shaper
5-12	Offset
5-13	Amplitude Modulator

When repairs have been made, paragraph 5-6 Power Supplies should always be checked. If readjustment is necessary, the whole adjustment procedure should be carried out.

Of the remaining paragraphs, only those which the repairs could affect need to be completed. Execute a paragraph completely and in the order in which it is presented. Only the significant instrument settings are given.

Allow 1 hour warm-up time before starting the adjustments.

5-5 ADJUSTMENTS

Set 8116A into service position as shown in Figure 5-1. At beginning of the procedure load the 8116A with its standard setting which is done by setting the 8116A to

MODE E.WID
OUTPUT sine

then turning the instrument off and on again.

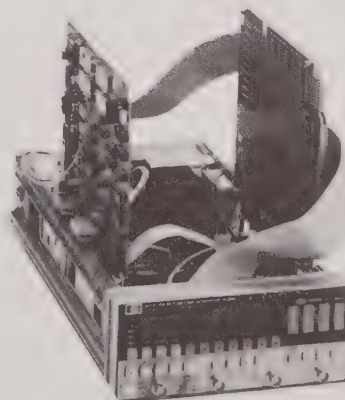


Figure 5-1. 8116A service position

If the 8116A is completely disarranged, it is recommended to turn A1R413 fully CW and A1R418 fully CCW, all other adjustment pots into their mid position.

5-6 POWER SUPPLIES

EQUIPMENT

Digital Voltmeter

PROCEDURE

1. Connect DVM low terminal to ground testpoint on A1 and measure the power supply output voltages.
2. Adjust supply voltages as follows:

TP	Adjust	Result
A1 +15 V	A1R24	+15.00 V $\pm$ 15 mV
A1 -5.2 V	A1R12	- 5.25 V $\pm$ 10 mV
A3 +5.0 V	check	+ 5.15 V $\pm$ 50 mV
A1 +5.0 V	check	+ 5.05 V $\pm$ 50 mV
A1 +24 V	A1R18	+24.00 V $\pm$ 50 mV
A1 -24 V	A1R19	-24.00 V $\pm$ 50 mV
A1 -15 V	A1R25	-15.00 V $\pm$ 15 mV

5-7 PRE-ADJUSTMENTS

EQUIPMENT

Real Time Scope

PROCEDURE

Square High Amplitude/Offset

1. Set 8116A:

MODE	NORM
FRQ	100 kHz
DTY	50 %
AMP	16.0 V
OFS	0.00 mV
OUTPUT	square, enabled

Connect 8116A output via 50 Ohm (2 W) feedthrough to Real Time Scope (2 V/Div.)

Adjust A1R410/R425 for a symmetrical 8 Div. signal.

Triangle high Amplitude/Offset

2. Set 8116A:

OUTPUT triangle, enabled

Adjust A1R227/R401 for a symmetrical 8 Div. signal.

Sine high Amplitude/Offset

3. Set 8116A:

OUTPUT sine, enabled

Adjust A1R418/R402 for a symmetrical 8 Div. signal.
Adjust A1R409 for optimal sinewave signal.

Square low Amplitude/Offset

4. Set 8116A:

AMP 1.00 V
OFS 0.00 mV
OUTPUT square, enabled

Set Real Time Scope to 200 mV/Div.

Turn A1 R450 fully CCW then adjust A1 R450/R416 for a symmetrical 5 Div. signal.

Sine low Amplitude

5. Set 8116A:

OUTPUT sine, enabled

Turn A1R445 fully CCW then adjust A1R445 for a 5 Div. signal.

Low Frequency Pulse Performance

6. Set 8116A:

FRQ 1 kHz
OUTPUT square, enabled

Adjust A1R515 for optimal squarewave signal.

5-8 OVERTSHOOT/TRANSITION TIMES

EQUIPMENT

Sampling scope

PROCEDURE

1. Set 8116A:

```

MODE ..... NORM
FRQ ..... 10.0 MHz
DTY ..... 50 %
AMP ..... 1.60 V
OFS ..... 0.00 mV
OUTPUT ..... triangle, enabled

```

Connect 8116A output to Sampling Scope.
Preadjust A1R535 for linear triangular waveform.

2. Set 8116A;

```

AMP ..... 16.0 V
OUTPUT ..... square,
                                normal/complement
                                as required enabled

```

Connect 8116A output via 20 dB attenuator to Sampling Scope. Adjust A1C529 for overshoot $< 4\%$ in both normal and complement modes.

3. Set 8116A:

AMP 1.00 V

Connect 8116A output without 20 dB attenuator to Sampling Scope. Adjust A1R535 for overshoot $< 4\%$ in both normal and complement modes.

4. Set 8116A:

AMP 16.0 V

Connect 8116A output via 20 dB attenuator to Sampling Scope. Check that overshoot $< 4\%$. If necessary, readjust A1R535.

5. Set 8116A:

AMP 1.00 V

Connect 8116A output without 20 dB attenuator to sampling scope. Check that transition times < 5.6 ns for both normal and complement modes.

6. Set 8116A:

AMP 999 mV

Check that transition times < 5.6 ns for both normal and complement modes.

7. Set 8116A:

AMP 1.00 V
OFS +7.50 V

Connect 8116A output via 20 dB attenuator to Sampling Scope. Check that transition times < 5.6 ns for both normal and complement modes.

Note: Transition times can be increased by increasing the overshoot. If Overshoot/Transition Times Adjustment cannot be achieved within specifications change * values A1C525, A1C530 (see table 5—1).

5-9 VOLTAGE CONTROLLED OSCILLATOR

EQUIPMENT

Counter, Sampling Scope, HF Spectrum Analyzer

PROCEDURE

Frequency/Duty Cycle (100 Hz – 999 kHz)

1. Set 8116A:

```

MODE ..... NORM
FRQ ..... 1.00 kHz
DTY ..... 50 %
AMP ..... 999 mV
OFS ..... 0.00 mV
OUTPUT ..... triangle, enabled

```

Set Counter: Time Interval $A \longrightarrow B$

Slope A 

Slope B

COM A

Trigger level 1.2 V

Connect 8116A trigger output via 50 Ohm feedthrough (or internal 50 Ohm termination) to counter.

Adjust A1 R22 for 500 us $\pm$ 0.5 us

2. Set 8116A:

FRQ 9.99 kHz

Adjust A2R24 for 50.05 us $\pm$ 0.05 us.

3. Repeat steps 1. and 2. until values remain within the given limits.

4. Set 8116A:

FRQ 1.00 kHz

Set Counter: Slope A 
 Slope B 

Adjust A2R25 for 500 us $\pm$ 0.5 us.

5. Set 8116A:

FRQ 9.99 kHz

Adjust A2R27 for 50.05 us $\pm$ 0.05 us

6. Repeat steps 4. and 5. until values remain within the given limits.

High Frequency (1 9.99 MHz Range)

7. Set 8116A:

FRQ 9.99 MHz

Set Counter: Frequency A

Adjust A1C204 for 9.99 MHz $\pm$ 0.1 MHz

Flatness

8. Set 8116A:

FRQ 1.00 MHz
AMP 999 mV
OUTPUT triangle, enabled

Connect 8116A output without 20 dB attenuator to Sampling Scope. Adjust Sampling Scope for 100 % display. Step 8116A up to 9.99 MHz. Observe amplitude flatness. The amplitude must decrease by 2 % to 4 %. Otherwise change* values A1R220/223 (see table 5-1).

High Frequency (10 50 MHz Range)

9. Set 8116A:

FRQ 10.0 MHz

Connect 8116A trigger output via 50 Ohm feedthrough (or internal 50 Ohm termination) to Counter.

Adjust A1R17 for 10.00 MHz $\pm$ 0.03 MHz.

10. Set 8116A:

FRQ 2.00 MHz
DTY 50 %
AMP 999 mV
OFS 0.00 mV
OUTPUT triangle, enabled

Connect 8116A output without 20 dB attenuator to Sampling Scope. Adjust Sampling Scope for 100 % display.

11. Set 8116A:

FRQ 50 MHz

Adjust A1R221/R224 for 51.0 MHz $\pm$ 0.5 MHz on counter and symmetrical output on Sampling Scope as shown in Figure 5-2.

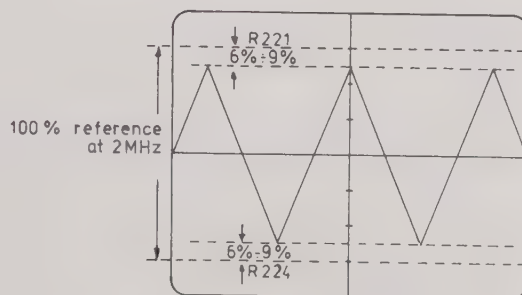


Figure 5-2. HF symmetry adjust

12. Connect 8116A output to HF Spectrum Analyzer (50 Ohm Termination). Readjust A1R221 for min. 2nd harmonic distortion with respect to best compromise between normal and complement mode. Readjust A1R224 for 51.0 MHz $\pm$ 0.5 MHz on counter.
13. Connect 8116A output to Sampling Scope. Check that the amplitude flatness is -10% to -18% corresponding to the 2 MHz reference.

The signal may not necessarily be symmetrical.

14. Set 8116A:

FRQ 42.0 MHz

Check that frequency < 43.5 MHz.

15. Check that amplitude flatness from 40 MHz to 50 MHz $> -20\%$ (100 % reference at 2 MHz).

16. Set 8116A:

FRQ 10.0 MHz
OUTPUT square, enabled

Adjust A1R130 for 50 % $\pm 10\%$ Duty Cycle.

Low Frequency (1 mHz – 99.9 Hz)

17. Set 8116A:

FRQ 99.9 Hz
DTY 50 %
AMP 1.00 V
OFS 0.00 mV
OUTPUT square, enabled

Adjust A2R18 for 99.9 Hz ± 0.1 Hz on Counter.

18. Set 8116A:

FRQ 9.99 Hz

19. Adjust A2R2 for 9.99 Hz ± 0.025 Hz.

20. Adjust A2R4 for Duty Cycle 50.00 % ± 0.2 %.

Note: If counter has no Duty Cycle Mode, use Time Interval Measurement from leading to trailing edge and from trailing to leading edge. The difference between both must be < 0.4 ms.

21. Repeat steps 19. and 20. until values remain within the given limits.

5–10 WIDTH

EQUIPMENT

Counter, Sampling Scope

PROCEDURE

1. Set 8116A:

MODE NORM
FRQ 900 Hz
WID 100 μ s
AMP 1.00 V
OFS 0.00 mV
OUTPUT pulse, normal, enabled

Set Counter: Time Interval A $\rightarrow$ B

Slope A 

Slope B 

COM A

Trigger level 0 V

Connect 8116A output via 50 Ohm feedthrough (or 50 Ohm termination of Counter) to Counter.

Adjust A2R32 for 98.0 μ s ± 2 μ s/ -1 μ s.

2. Set 8116A:

WID 999 μ s

Adjust A1R304 for 980 μ s ± 20 μ s / -10 μ s.

3. Repeat steps 1. and 2. until values remain within the given limits.

4. Set 8116A:

WID 400 μ s

Check that width > 386 μ s.

If not, repeat steps 1. and 2.

5. Set 8116A:

FRQ 100 kHz
WID 99.9 ns

Adjust A2R31 for 99.9 ns ± 1 ns.

6. Set 8116A:

WID 100 ns

Check width for $100 \text{ ns} \pm 5 \text{ ns}$.

7. Set 8116A:

FRQ 10.0 MHz

WID 8.0 ns

Connect 8116A output to Sampling Scope.

Check that $7.5 \text{ ns} < \text{Width} < 10 \text{ ns}$.

8. Set 8116A:

MODE NORM

CRTL PWM

FRQ 1.00 kHz

WID 550 μs

AMP 1.00 V

OFS 0.00 mV

OUTPUT pulse, normal,
enabled

Connect 8116A output via 50 Ohm feedthrough to Counter. (Or use internal 50 Ohm termination of the counter).

Check that width equals $550 \mu\text{s} \pm 20 \mu\text{s}$.

If not, change * value A1R157 (see table 5–1).

Set DVM: AC, 10 V Range

Connect 8116A output via 50 Ohm feedthrough to DVM.

Adjust A1R410 for $5.055 \text{ V} \pm 25 \text{ mV RMS}$.

3. Set 8116A:

AMP 16.0 V

Check amplitude $> 8.080 \text{ V}$ (typ. 8.082 V).

4. Set 8116A:

AMP 1.00 V

Adjust A1R450 for $0.506 \text{ V} \pm 2 \text{ mV RMS}$.

Square Normal/Complement Balance

5. Set 8116A:

AMP 16.0 V

OFS 0.00 mV

OUTPUT square,
normal/complement as
required, enabled

Set DVM: DC, 10 V Range.

Use DVM built in filter function, otherwise
use set up as shown in figure 5–3.

5–11 SHAPER

EQUIPMENT

Digital Voltmeter (RMS), LF Spectrum Analyser,
Low Pass Filter as shown in figure 5–3.

PROCEDURE

1. Turn A1R413 fully CW
Turn A1R418 fully CCW

Square Amplitude

2. Set 8116A:

MODE NORM

FRQ 1.00 kHz

DTY 50 %

AMP 9.99 V

OFS 0.00 mV

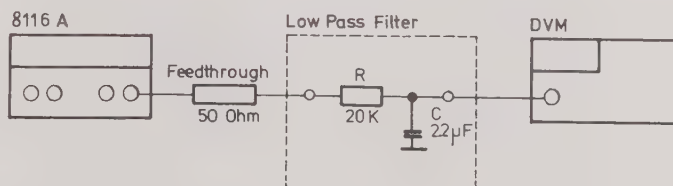
OUTPUT square, normal
enabled

Figure 5–3. Low-pass filter test setup

Change 8116A output mode from normal to complement and back. Adjust A1R403 for minimum difference ($< 5 \text{ mV}$) between normal and complement output mode.

Triangle Amplitude

6. Set 8116A:

```
AMP ..... 9.99 V
OUTPUT ..... triangle, normal,
                enabled
```

Set DVM: AC, 10 V Range

Adjust A1R227 for $2.918 \text{ V} \pm 15 \text{ mV RMS}$

7. Set 8116A:

AMP 16.0 V

Check that amplitude > 4.660 V.

2nd Harmonic Distortion

8. Set 8116A:

```

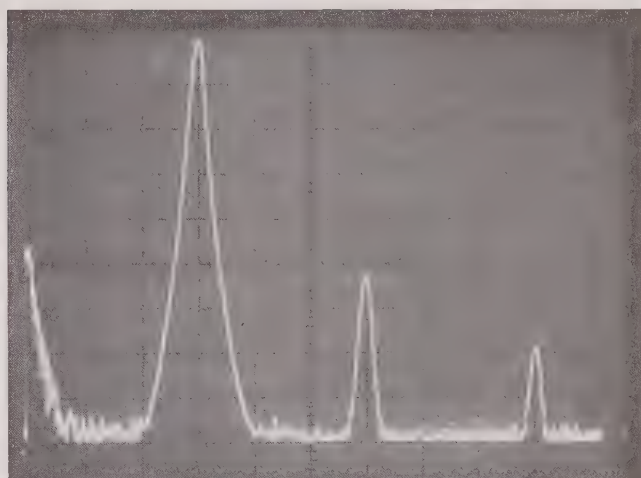
FRQ ..... 3.00 kHz
AMP ..... 16.0 V
OUTPUT ..... sine,
                    normal/complement as
                    required enabled

```

Connect 8116A output via 50 Ohm (2 W) feedthrough to LF Spectrum Analyzer adjusting the input amplifier so that the fundamental equals 0 dB on display.

Preadjust A1R409 for minimum 3rd harmonic in normal mode. Adjust A1R417 for minimum 2nd harmonic in normal mode. Change 8116A from normal to complement mode and back. Adjust A1R407 for minimum difference between the 2nd harmonics in normal and complement mode.

Note: 2nd harmonic should be < -48 dB for both normal and complement modes.
The difference between normal and complement mode must not exceed 5 dB. To achieve this, alternating adjustment of A1R417 and A1R407 may be necessary.



3kHz

Figure 5-4. 2nd harmonic distortion adjust.

Sine Normal/Complement balance

9. Set 8116A:

```

FRQ ..... 1.00 kHz
AMP ..... 16.00 V
OFS ..... 0.00 mV
OUTPUT ..... sine,
normal/complement as
required enabled

```

Set DVM: DC, 10 V Range

Connect 8116A output via 50 Ohm feedthrough to DVM. Use DVM built in filter function, otherwise use set-up as shown in figure 5-3.

Change 8116A output mode from normal to complement and back. Adjust A1R402 for minimum difference ($< 5 \text{ mV}$) between normal and complement output mode

If the adjustment is not possible, change * value A1R439 (see table 5–1) and repeat the procedure from step 5.

Sine Amplitude/THD

10. Set 8116A:

FRQ 1.00 kHz
AMP 9.99 V

Set DVM: AC, 10 V Range

Connect 8116A via 50 Ohm feedthrough to DVM.
Adjust A1R418 for $3.532 \text{ V} \pm 10 \text{ mV RMS}$.

11. Set 8116A:

AMP 1.00 V

Adjust A1R445 for $0.354 \text{ V} \pm 1 \text{ mV RMS}$.

12. Set 8116A:

FRQ 3.00 kHz
AMP 9.99 V
OUTPUT normal

Connect 8116A output via 50 Ohm feedthrough to LF Spectrum Analyzer adjusting its input amplifier so that the fundamental equals 0 dB on display.

Adjust A1R409 for minimum 3rd harmonic.

It should be $< -50 \text{ dB}$

13. Repeat steps 10 through 12 until values are within the given limits.

14. Set 8116A:

FRQ 1.00 kHz
AMP 16.0 V

Connect 8116A output via 50 Ohm feedthrough to DVM. Readjust A1R448 for 5.655 to 5.741 V RMS .

Triangle Normal/Complement Balance

15. Set 8116A:

FRQ 1.00 kHz
AMP 16.0 V
OFS 0.00 mV
OUTPUT triangle,
normal/complement as
required enabled

Set DVM: DC, 10 V Range

Connect 8116A output via 50 Ohm feedthrough to DVM, use built-in filter function, otherwise use set-up as shown in figure 5-3.

Change 8116A output mode from normal to complement and back. Adjust A1R401 for minimum difference ($< 5 \text{ mV}$) between normal and complement output mode.

If adjustment is not possible, change * value A1R439 (see table 5-1) and repeat the procedure from step 5.

Sine Offset

16. Set 8116A:

AMP 16.0 V
OFS 0.00 mV
OUTPUT sine, normal,
enabled

Adjust A1R425 for $0.00 \text{ V} \pm 10 \text{ mV}$.

17. Set 8116A:

AMP 1.00 V

Adjust A1R416 for $0.00 \text{ V} \pm 5 \text{ mV}$.

Square low Amplitude

18. Set 8116A:

AMP 1.00 V
OFS 0.00 mV
OUTPUT square, normal,
enabled

Set DVM: AC, 10 V Range

Connect 8116A output via 50 Ohm feedthrough to DVM
Readjust A1R450 for $0.506 \text{ V} \pm 2 \text{ mV RMS}$.

THD Check

19. Set 8116A:

FRQ 3.00 kHz
AMP 1.00 V
OUTPUT sine, normal /
complement as required.

Connect 8116A output via 50 Ohm feedthrough to LF Spectrum Analyzer and adjusting the input amplifier so that the fundamental equals 0 dB on display.

Check that 2nd harmonic < -45 dB in both normal and complement modes.

20. Set 8116A;

- FRQ 50 MHz
- AMP 100 mV

Connect 8116A output to HF Spectrum Analyzer (50 Ohm feedthrough or termination) and adjust its input amplifier so that fundamental equals 0 dB on display.

Check that 2nd and 3rd harmonic < -27 dB in both normal and complement.

5-12 OFFSET

EQUIPMENT

Digital Voltmeter

PROCEDURE

1. Set 8116A:

- MODE NORM
- FRQ 1.00 kHz
- DTY 50 %
- AMP 100 mV
- OFS +7.95 V
- OUTPUT sine, normal, enabled

Set DVM: DC, 10 V Range

Connect 8116A output via 50 Ohm feedthrough to DVM. Use DVM built in filter function, otherwise use set-up shown in figure 5-3.
Adjust A2 R43 for +7.97 V ±30 mV.

2. Set 8116A:

- OFS -7.95 V

Check that offset equals -7.97 V ± 30 mV.

5-13 AMPLITUDE MODULATOR

EQUIPMENT

Signal Generator (THD < 0.1 %), Real Time Scope, LF Spectrum Analyzer

PROCEDURE

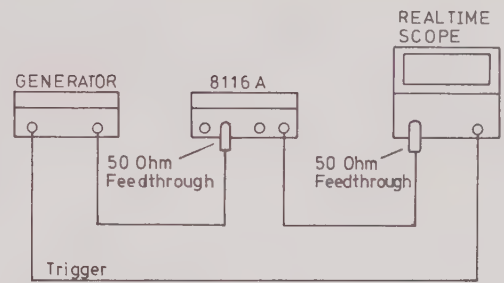


Figure 5-5. AM offset test setup

1. Set 8116A:

- MODE NORM
- CRTL AM
- FRQ 100 kHz
- DTY 50 %
- AMP 16.0 V
- OFS 0.00 mV
- OUTPUT sine, normal/complement as required enabled

Set Signal Generator:

- FREQUENCY 5.0 kHz
- AMPLITUDE ca. 5 V as required
- OFFSET 0 V
- WAVEFORM sine

Use set-up as shown in figure 5-5.

Adjust amplitude of signal generator so that the maximum amplitude of the 8116A modulated output signal equals 16 V on Real Time Scope display.

2. Change 8116A output mode from normal to complement and back. Adjust A1R414 for minimum offset difference at the 8116A modulated output signal's minimum amplitude between normal and complement mode:
3. Adjust A1R413 for the mean (medium) modulation between the actual modulation and 100 % modulation.

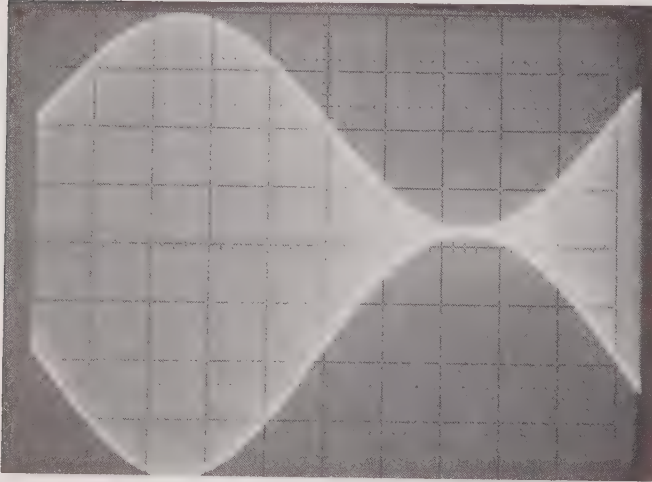


Figure 5-6 (a). Incorrect AM offset

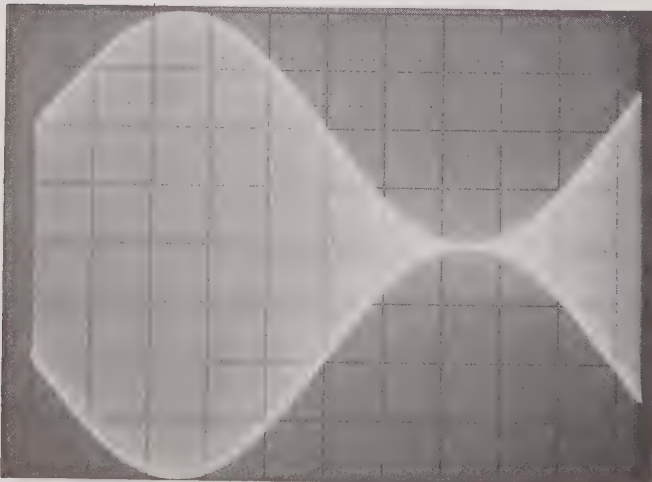


Figure 5-6 (b). Correct AM offset

4. Repeat steps 2. and 3. until 100 % modulation with minimum offset difference between normal and complement mode is reached.

5. Set 8116A:

FRQ 15.0 kHz
 OUTPUT sine, normal, enabled

Set Signal Generator:

FREQUENCY 2.0 kHz
 AMPLITUDE 4.5 V
 OFFSET 0.25 V
 WAVEFORM sine

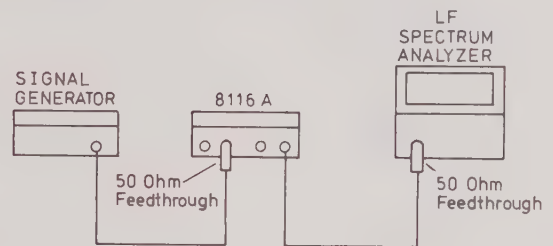


Figure 5-7. AM envelope test setup

Use set-up as shown in figure 5-7.

Adjust the Spectrum Analyzer to display the 15 kHz carrier and the lower sideband frequencies down to the 2 kHz modulating frequency. Adjust input amplifier of the Spectrum Analyzer so that the carrier equals 0 dB on display.

6. Adjust A1R414 for minimum 2 kHz modulating frequency.

7. Verify that envelope distortion < 40 dB. All harmonics of the sideband should be at least 42 dB lower than the modulation sidebands.

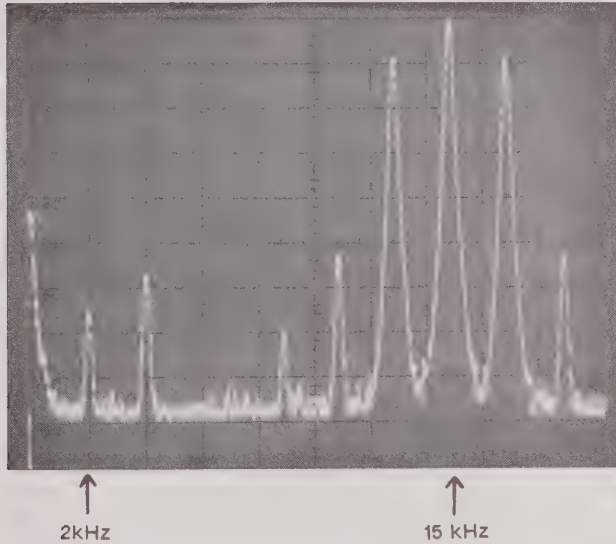
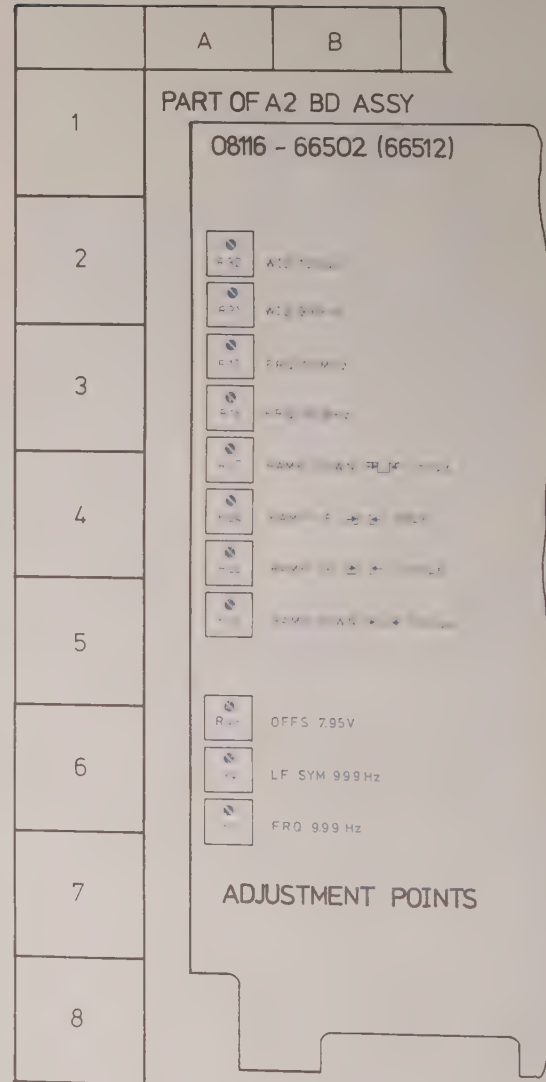
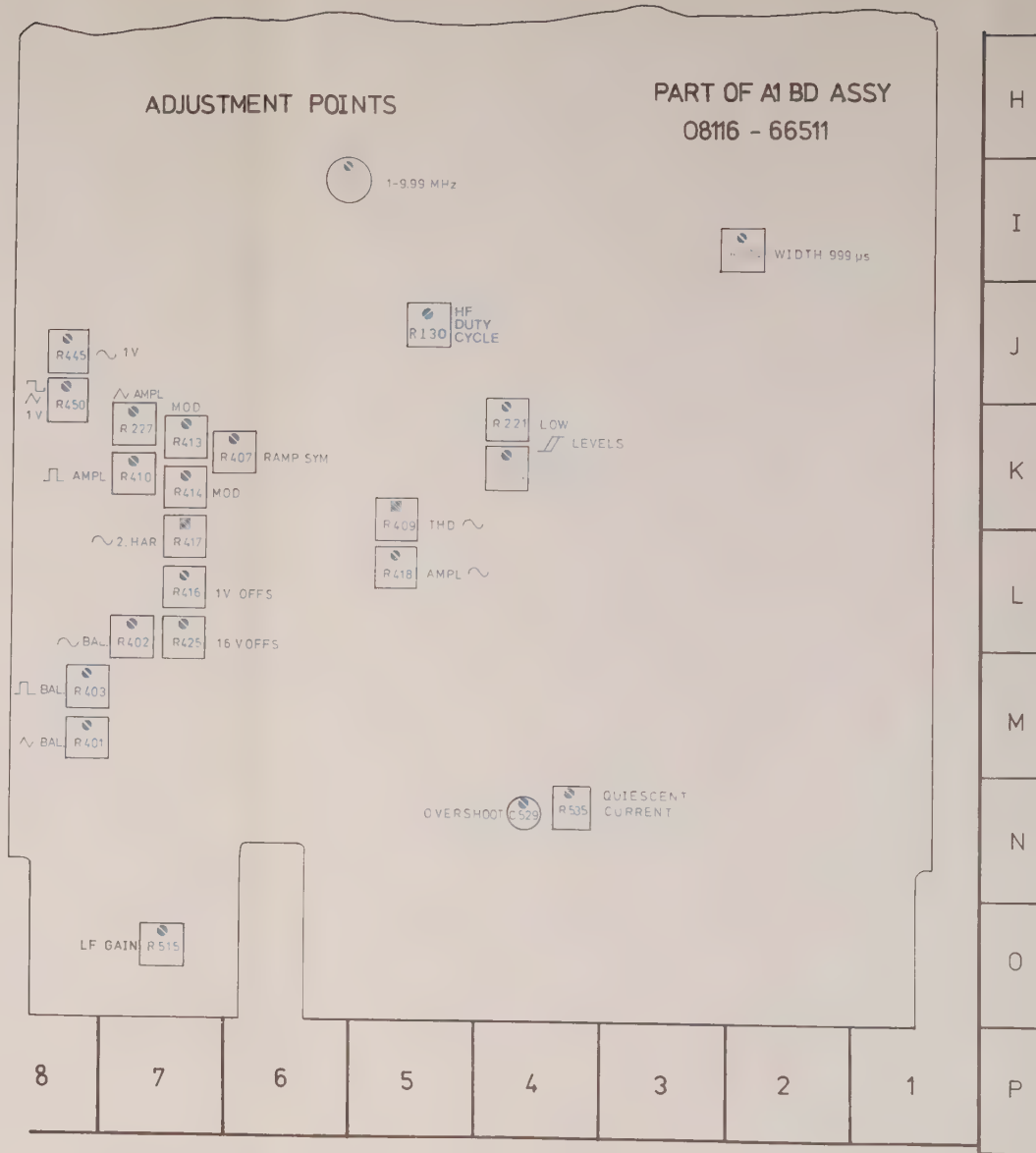
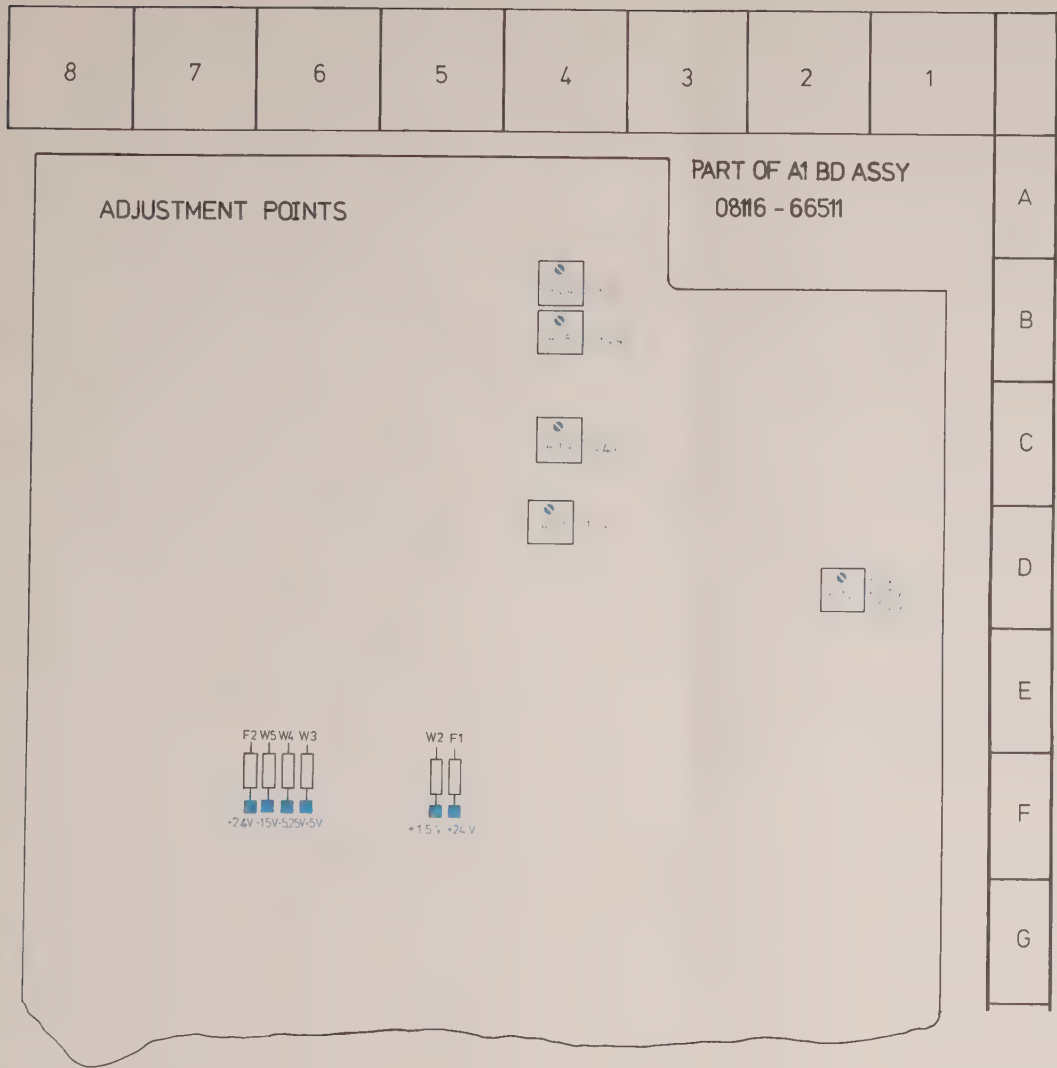


Figure 5-8. AM Envelope Distortion

8. Recheck and if necessary readjust steps 9., 11., 15. and 18. of paragraph 5-11 Shaper.
9. Verify again step 7.



SECTION VI REPLACEABLE PARTS

6-1 INTRODUCTION

6-2 This section contains information for ordering parts. Table 6-1 lists abbreviations used in the parts lists and elsewhere in the manual. Table 6-3 lists all replaceable parts in reference designator order.

6-3 ABBREVIATIONS

6-4 Table 6-1 lists abbreviations used in the parts lists, schematics and elsewhere in the manual. In some cases two forms of the abbreviations are used, one all in capital letters, and one partial or no capitals. This occurs because the abbreviations in the parts lists are always all capitals. However, in the schematics and other parts of the manual, the same abbreviations may have upper and lower case letters.

6-5 REPLACEABLE PARTS

6-6 Table 6-3 is the list of replaceable parts and is organised as follows:

- a. Mainframe (chassis) parts in alphanumerical order by reference designation.
- b. Electrical assemblies and their components in alpha-numerical order by reference designation.

Reference designators are of the form A3R9 i.e. resistor 9 assembly 3. The blue pages at the end of this section list the parts required for Option 001.

6-7 The information given for each part consists of the following:

- a. The Hewlett-Packard part number.
- b. The description of the part.
- c. Part number check digit (CD).

6-8 ORDERING INFORMATION

6-9 To order a part listed in the replaceable parts table, quote the Hewlett-Packard part number (with check digit), indicate the quantity required, and address the order to the nearest Hewlett-Packard office (list of Sales/Service offices at the rear of this manual). The check digit will ensure accurate and timely processing of your order.

6-10 To order a part that is not listed in the replaceable parts table, include the instrument model number, instrument serial number, the description and function of the part, and the number of parts required, address the order to the nearest Hewlett-Packard office.

6-11 DIRECT MAIL ORDER SYSTEM(USA)

6-12 Within the USA, Hewlett-Packard can supply parts through a direct mail order system. Advantages of using the system are as follows:

- a. Direct ordering and shipment from the HP Parts Center in Mountain View, California.
- b. No maximum or minimum on any mail order (there is a minimum order amount for parts ordered through a local HP office when the orders require billing and invoicing).
- c. Prepaid transportation (there is a small handling charge for each order).
- d. No invoices — to provide these advantages, a check or money order must accompany each order.

6-13 Mail order forms and specific ordering information is available through your local HP office. Addresses and phone numbers are located at the back of this manual.

Table 6-1. Abbreviations for Replaceable Parts List

REFERENCE DESIGNATIONS

A assembly	E miscellaneous electrical part	P electrical connector (movable portion); plug	VR voltage regulator; breakdown diode
AT attenuator; isolator; termination	F fuse	Q transistor; SCR; triode thyristor	W cable; transmission path; wire
B fan; motor	FL filter	R resistor	X socket
BT battery	H hardware	RT thermistor	Y crystal unit (piezo-electric or quartz)
C capacitor	HY circulator	S switch	Z tuned cavity; tuned circuit
CP coupler	J electrical connector (stationary portion); jack	T transformer	
CR diode; diode thyristor; varactor		TB terminal board	
DC directional coupler		TC thermocouple	
DL delay line	K relay	TP test point	
DS annunciator; signaling device (audible or visual); lamp; LED	L coil; inductor	U integrated circuit; microcircuit	
	M meter	V electron tube	
	MP miscellaneous mechanical part		

ABBREVIATIONS

A ampere	CW continuous wave	h hour	MET OX metallic oxide
ac alternating current	cw clockwise	HET heterodyne	MF medium frequency; microfarad (used in parts list)
ACCESS accessory	cm centimeter	HEX hexagonal	MFR manufacturer
ADJ adjustment	D/A digital-to-analog	HD head	mg milligram
A/D analog-to-digital	dB decibel	HDW hardware	MHz megahertz
AF audio frequency	dBm decibel referred to 1 mW	HF high frequency	mH millihenry
AFC automatic frequency control	dc direct current	HG mercury	mho mho
AGC automatic gain control	deg degree (temperature interval or difference)	HI high	MIN minimum
AL aluminum	° degree (plane angle)	HP Hewlett-Packard	min minute (time)
ALC automatic level control	°C degree Celsius (centigrade)	HPF high pass filter	minute (plane angle)
AM amplitude modulation	°F degree Fahrenheit	HR hour (used in parts list)	
AMPL amplifier	°K degree Kelvin	HV high voltage	MINAT miniature
APC automatic phase control	DEPC deposited carbon	Hz Hertz	mm millimeter
ASSY assembly	DET detector	IC integrated circuit	MOD modulator
AUX auxiliary	diam diameter	ID inside diameter	MOM momentary
avg average	DIA diameter (used in parts list)	IF intermediate frequency	MOS metal-oxide semiconductor
AWG American wire gauge	DIFF AMPL differential amplifier	IMPG impregnated	ms millisecond
BAL balance	div division	in inch	MTG mounting
BCD binary coded decimal	DPDT double-pole, double-throw	INCD incandescent	MTR meter (indicating device)
BD board	DR drive	INCL include(s)	mV millivolt
BE CU beryllium copper	DSB double sideband	INP input	mVac millivolt, ac
BFO beat frequency oscillator	DTL diode transistor logic	INS insulation	mVdc millivolt, dc
BH binder head	DVM digital voltmeter	INT internal	mVpk millivolt, peak
BKDN breakdown	FCL emitter coupled logic	kg kilogram	mVp-p millivolt, peak-to-peak
BP bandpass	EMF electromotive force	kHz kilohertz	mVrms millivolt, rms
BPF bandpass filter	EDP electronic data processing	k Ω kilohm	mW milliwatt
BRS brass	ELECT electrolytic	kV kilovolt	MUX multiplex
BWO backward-wave oscillator	ENCAP encapsulated	lb pound	MY mylar
CAL calibrate	EXT external	LC inductance-capacitance	μ A microampere
ccw counter-clockwise	F farad	LED light-emitting diode	μ F microfarad
CER ceramic	FET field-effect transistor	LF low frequency	μ H microhenry
CHAN channel	F/F flip-flop	LG long	μ mho micromho
cm centimeter	FH flatt head	LH left hand	μ s microsecond
CMO cabinet mount only	FIL H fillister head	LIM limit	μ V microvolt
COAX coaxial	FM frequency modulation	LIN linear taper (used in parts list)	μ Vac microvolt, ac
COEF coefficient	FP front panel	lin linear	μ Vdc microvolt, dc
COM common	FREQ frequency	LK WASH lock washer	μ Vp-p microvolt, peak-to-peak
COMP composition	FXD fixed	LO low; local oscillator	μ Vrms microvolt, rms
COMPL complete	g gram	LOG logarithmic taper (used in parts list)	μ W microwatt
CONN connector	GE germanium	log logarithm(ic)	nA nanoampere
CP cadmium plate	GHz gigahertz	LPF low pass filter	NC no connection
CRT cathode-ray tube	GL glass	LV low voltage	N/C normally closed
CTL complementary transistor logic	GRD ground(ed)	m meter (distance)	NE neon
	H henry	mA milliampere	NEG negative
		MAX maximum	nF nanofarad
		M Ω megohm	NI PL nickel plate
		MEG meg (10 ⁶) (used in parts list)	N/O normally open
		MET FLM metal film	NOM nominal

NOTE

All abbreviations in the parts list will be in upper-case.

Table 6-1. Abbreviations for Replaceable Parts List (cont'd)

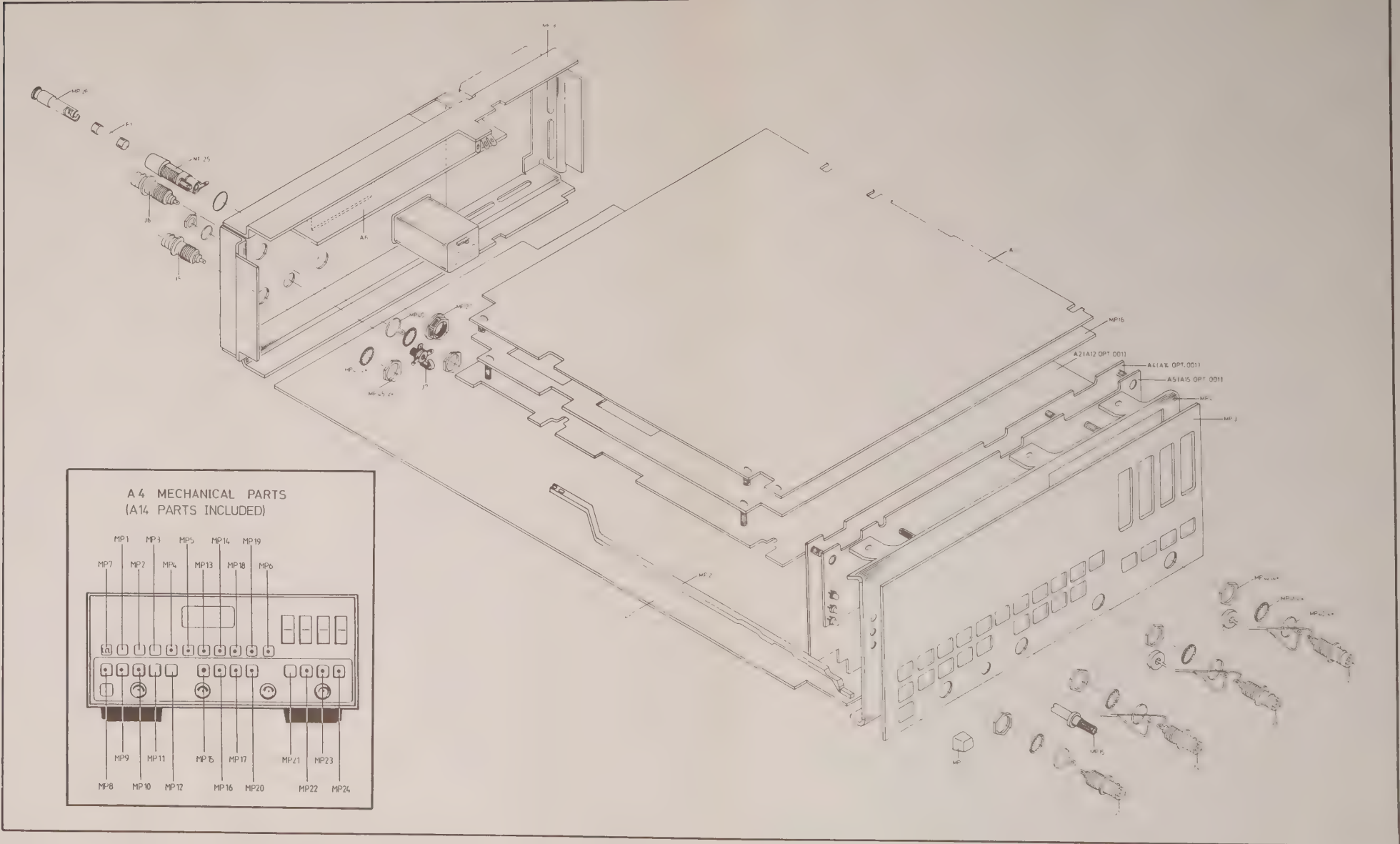
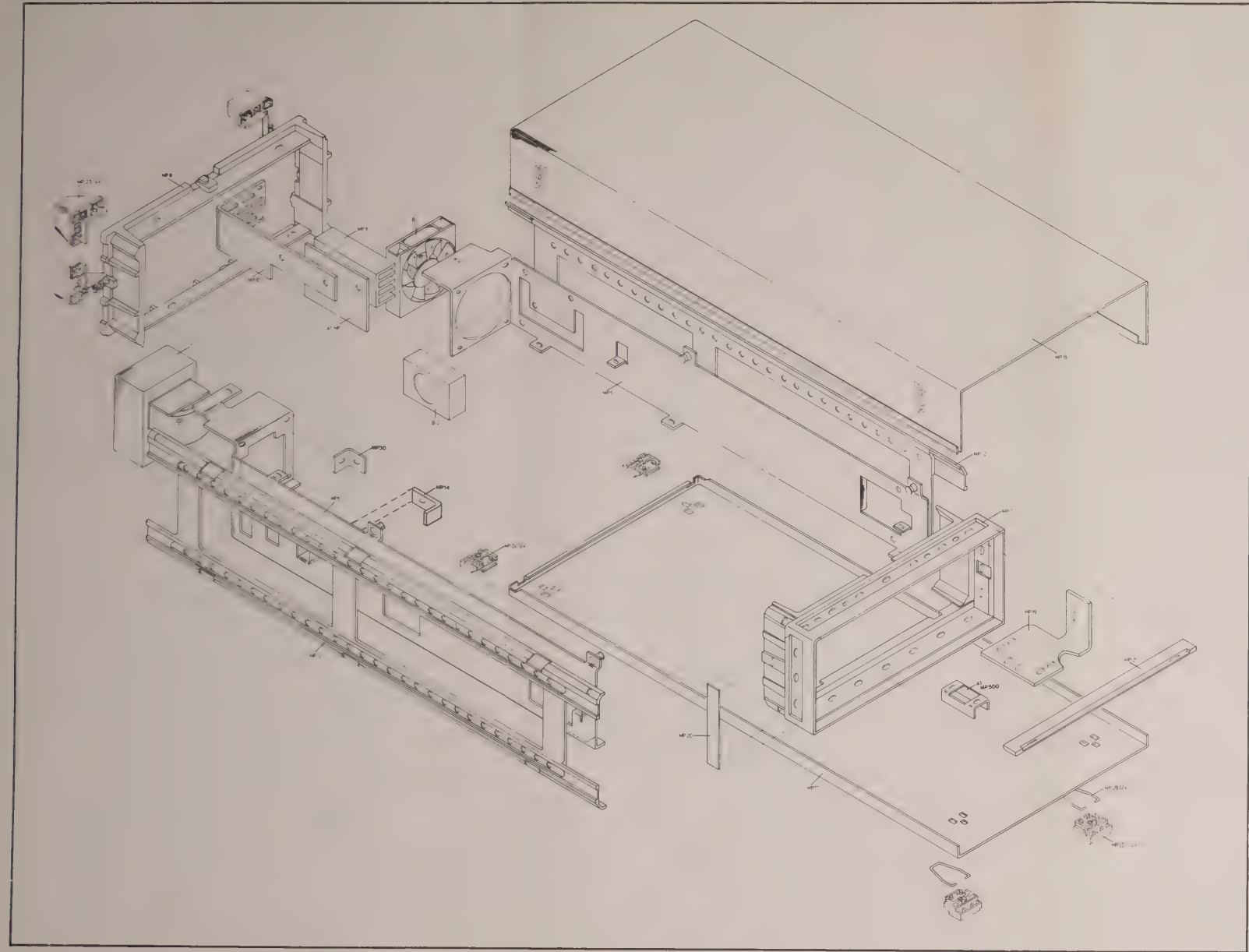
NORM normal	POT [†] potentiometer	SI silicon	VFO variable-frequency oscillator
NPN negative-positive-negative	p-p peak-to-peak	SIL silver	VHF very-high frequency
NPO negative-positive zero (zero temperature coefficient)	PP peak-to-peak (used in parts list)	SL slide	Vpk volts, peak
NRFR not recommended for field replacement	PPM pulse-position modulation	SNR signal-to-noise ratio	Vp-p volts, peak-to-peak
NSR not separately replaceable	PREAMPL preamplifier	SPDT single-pole, double-throw	Vrms volts, rms
ns nanosecond	PRF pulse-repetition frequency	SPG spring	VSWR voltage standing wave ratio
nW nanowatt	PRR pulse repetition rate	SR split ring	VTO voltage-tuned oscillator
OBD order by description	ps picosecond	SPST single-pole, single-throw	VTVM Vacuum-tube voltmeter
OD outside diameter	PT point	SSB single sideband	V(X) volts, switched
OH oval head	PTM pulse-time modulation	SST stainless steel	W watt
OP AMPL operational amplifier	PWM pulse-width modulation	STL steel	W with
OPT option	PWV peak working voltage	SQ square	W without
OSC oscillator	RC resistance-capacitance	SWR standing-wave ratio	WIV working inverse voltage
OX oxide	RECT rectifier	SYNC synchronize	WW wirewound
oz ounce	REF reference	T timed (slow-blow fuse)	W/O without
Ω ohm	REG regulated	TA tantalum	YIG yttrium-iron-garnet
P peak (used in parts list)	REPL replaceable	TC temperature compensating	Z ₀ characteristic impedance
PAM pulse-amplitude modulation	RF radio frequency	TD time delay	
PC printed circuit	RFI radio frequency interference	TERM terminal	
PCM pulse-code modulation; pulse-count modulation	RH round head; right hand	TFT thin-film transistor	
PDM pulse-duration modulation	RLC resistance-inductance-capacitance	TGL toggle	
pF picofarad	RMO rack mount only	THD thread	
PH BRZ phosphor bronze	rms root-mean-square	THRU through	
PHL Phillips	RND round	TI titanium	
PIN positive-intrinsic-negative	ROM read-only memory	TOL tolerance	
PIV peak inverse voltage	R&P rack and panel	TRIM trimmer	
pk peak	RWV reverse working voltage	TSTR transistor	
PL phase lock	S scattering parameter	TTL transistor-transistor logic	
PLO phase lock oscillator	s second (time)	TV television	
PM phase modulation	" second (plane angle)	TVI television interference	
PNP positive-negative-positive	S-B slow-blow (fuse) (used in parts list)	TWT traveling wave tube	
P/O part of	SCR silicon controlled rectifier; screw	U micro (10 ⁶) (used in parts list)	
POLY polystyrene	SE selenium	UF microfarad (used in parts list)	
PORC porcelain	SECT sections	UHF ultrahigh frequency	
POS positive; position(s) (used in parts list)	SEMICON semiconductor	UNREG unregulated	
POSN position	SHF superhigh frequency	V volt	
		VA voltampere	
		Vac volts, ac	
		VAR variable	
		VCO voltage-controlled oscillator	
		Vdc volts, dc	
		VDCW volts, dc, working (used in parts list)	
		V(F) volts, filtered	

MULTIPLIERS

Abbreviation	Prefix	Multiple
T	tera	10 ¹²
G	giga	10 ⁹
M	mega	10 ⁶
k	kilo	10 ³
da	deka	10
d	deci	10 ⁻¹
c	centi	10 ⁻²
m	milli	10 ⁻³
μ	micro	10 ⁻⁶
n	nano	10 ⁻⁹
p	pico	10 ⁻¹²
f	femto	10 ⁻¹⁵
a	atto	10 ⁻¹⁸

NOTE

All abbreviations in the parts list will be in upper-case.



A 4 MECHANICAL PARTS
(A14 PARTS INCLUDED)

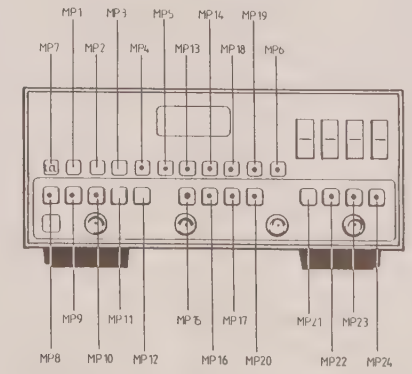


Table 6-3. Replaceable Parts

REFERENCE DESIGNATOR	C D	H-P PART NUMBER	DESCRIPTION
FRAME			
A1		08116-66511	BD AY-MAIN
A2	5	08116-66502	BD AY-CONTROL
A3	7	08116-66503	BD AY-MICROPRCR
A4	8	08116-66504	BD AY-KEY
A5	9	08116-66505	BD AY DISPLAY
A6		08116-66506	BD AY HPIB
B1	3	3160-0266	FAN TUBE AXIAL
B2	3	3160-0310	MODULE MOTOR CON
F1	8	2110-0043	FUSE 1.5 FER
F1	2	2110-0063	FUSE .75 FER
FL1		9135-0035	FILTER, LINE
J1	1	1250-0083	CONN BNC BLKHD
J2	1	1250-0083	CONN BNC BLKHD
J3	1	1250-0083	CONN BNC BLKHD
J4	1	1250-0083	CONN BNC BLKHD
L1	5	9170-0013	CORE FERRA .375
L2	5	9170-0013	CORE FERRA .375
MP1	5	5041-0531	KEY
MP2	1	5040-9317	SHAFT-POWER-SW
MP3	7	4040-1972	PANEL FRONT
MP4	5	08116-00202	PANEL-SUB
MP5		08112-04156	BRACKET FAN
MP6		08112-04153	BRACKET-XFMR
MP7	8	5020-8813	FRAME FRONT
MP8		08116-21103	FRM REAR(MODIFY)
MP9		5061-2116	PANEL REAR
MP10		08112-21101	HEATSINK-REAR
MP11		08112-21105	HEATSINK-POWER
MP12	0	5020-8831	SIDE STRUT 17IN
MP13	0	5020-8831	SIDE STRUT 17IN
MP14		08112-04154	KEEPER
MP15	6	5040-1136	KNOB LONG
MP16		08112-00601	SHIELD
MP17	4	08112-04158	COVER-BOTTOM
MP18		08116-04101	COVER TOP 31/2HM
MP19		08116-21102	HEATSINK OUTPUT
MP20	7	5001-0438	TRIM STRIP
MP21	0	5040-7203	TRIM STRIP
MP22	8	5040-7201	FOOT
MP23	2	5040-7221	FOOT REAR
MP24	3	5040-7222	RR FEET NON-SKID
MP25	8	2110-0564	FUSEHOLDER BODY
MP26	9	2110-0565	FUSEHOLD CAP/UL
MP27	3	2110-0569	NUT HEX
MP28	5	1460-1345	TILT STAND
MP30		1400-0290	BRACKET 90°
MP31		1400-0024	CABLE CLAMP
MP32	4	0380-0644	MTG STUD
MP33		08116-40601	COVER-PLASTIC
MP40	5	0360-1190	TERM-LUG SLDR
MP41	3	2190-0016	WASH-LOCK INT3/8
MP42	8	2950-0043	NUT-HEX .375-32
T1		08112-61101	XFMR-PWR

Table 6-3. Replaceable Parts

REFERENCE DESIGNATOR	C	D	H-P PART NUMBER	DESCRIPTION	REFERENCE DESIGNATOR	C	D	H-P PART NUMBER	DESCRIPTION
A1			08116-66511	BD AY-MAIN	A1	C226	9	0160-0174	C-F .47UF 25VCER
A1	C1		0180-3159	C-F ELCO 1000UF	A1	C227	9	0160-0174	C-F .47UF 25VCER
A1	C2		0180-3158	C-F ELCO 6800UF	A1	C230	3	0160-4386	C-F 33PF 5% 200V
A1	C3		0180-3160	C-F ELCO 2200UF	A1	C231	5	0160-0576	C-F .1UF 20% CER
A1	C4		0180-3160	C-F ELCO 2200UF	A1	C235		0160-4494	C-F 39 PF 200V 10%
A1	C5		0180-3152	C-FXD 2200UF 40V	A1	C240	9	0160-0174	C-F .47UF 25VCER
A1	C6	6	0180-3008	C-F 470UF 10%	A1	C241	5	0160-0576	C-F .1UF 20% CER
A1	C7	7	0180-2984	C-F 47UF 20% 50V	A1	C260	5	0160-0576	C-F .1UF 20% CER
A1	C8	7	0180-2984	C-F 47UF 20% 50V	A1	C261	5	0160-0576	C-F .1UF 20% CER
A1	C9	7	0180-2984	C-F 47UF 20% 50V	A1	C262	7	0160-3879	C-F .01UF 100V
A1	C10	7	0180-2984	C-F 47UF 20% 50V	A1	C263	5	0160-0576	C-F .1UF 20% CER
A1	C11	9	0180-2962	C-F 220UF 10V	A1	C264 *		0160-4040	C-F 1nF 100V 5%
A1	C12	9	0180-2962	C-F 220UF 10V	A1	C300	2	0160-3874	C-F 10PF 200V
A1	C13	9	0180-2962	C-F 220UF 10V	A1	C301	5	0160-0576	C-F .1UF 20% CER
A1	C14	9	0160-2055	C-F .01UF CER	A1	C302	5	0160-0576	C-F .1UF 20% CER
A1	C15	9	0160-2055	C-F .01UF CER	A1	C303	7	0160-3879	C-F .01UF 100V
A1	C16	9	0160-2055	C-F .01UF CER	A1	C304	6	0160-3878	C-F .001UF 100V
A1	C17	9	0160-2055	C-F .01UF CER	A1	C305	5	0160-0576	C-F .1UF 20% CER
A1	C18	1	0160-3097	C-F .47UF CER	A1	C306	7	0160-3879	C-F .01UF 100V
A1	C19	1	0160-3097	C-F .47UF CER	A1	C400	7	0160-3879	C-F .01UF 100V
A1	C100	5	0160-0576	C-F .1UF 20% CER	A1	C401	1	0160-0572	C-F 2200PF CER
A1	C101	5	0160-0576	C-F .1UF 20% CER	A1	C402	9	0160-0174	C-F .47UF 25VCER
A1	C102	9	0160-0174	C-F .47UF 25VCER	A1	C403	5	0160-0576	C-F .1UF 20% CER
A1	C103	5	0160-0576	C-F .1UF 20% CER	A1	C404	9	0160-0174	C-F .47UF 25VCER
A1	C104	0	0160-0571	C-F 470PF 20% CER	A1	C405	5	0160-0576	C-F .1UF 20% CER
A1	C105	5	0160-0174	C-F .47UF 25V	A1	C406	7	0160-4512	C-F 120PF 5%
A1	C106	5	0160-0576	C-F .1UF 20% CER	A1	C408		0160-0576	C-F .1UF 20%
A1	C107	7	0180-0229	C-F 33UF 10V	A1	C501	3	0160-0574	C-F .022UF CER
A1	C108	5	0160-0576	C-F .1UF 20% CER	A1	C502	7	0160-4547	C-F 150PF 200V 5%
A1	C110	9	0160-0174	C-F .47UF 25VCER	A1	C503	9	0160-0174	C-F .47UF 25VCER
A1	C112	1	0180-2249	C-F 47UF ±10% 20V	A1	C504	9	0160-0174	C-F .47UF 25VCER
A1	C113	1	0180-2249	C-F 47UF ±10% 20V	A1	C505	7	0160-3879	C-F .01UF 100V
A1	C114	7	0180-0229	C-F 33UF 10V	A1	C506	1	0160-0572	C-F 2200PF CER
A1	C115	7	0180-0229	C-F 33UF 10V	A1	C507	1	0160-3097	C-F .47UF CER
A1	C151	1	0160-3873	C-F 4.7PF 200V	A1	C508	1	0160-3097	C-F .47UF CER
A1	C152	5	0160-0576	C-F .1UF 20% CER	A1	C509	2	0160-0573	C-F 4700PF 20%
A1	C153	5	0160-0576	C-F .1UF 20% CER	A1	C510	2	0160-0573	C-F 4700PF 20%
A1	C154	4	0160-4387	C-F 47PF 200V	A1	C511	7	0160-3879	C-F .01UF 100V
A1	C200	6	0160-3878	C-F 001UF 100V	A1	C512	5	0160-0576	C-F .1UF 20% CER
A1	C201	6	0160-3878	C-F 001UF 100V	A1	C513	5	0160-0576	C-F .1UF 20% CER
A1	C202	7	0160-3879	C-F .01UF 100V	A1	C514	5	0160-0576	C-F .1UF 20% CER
A1	C204	2	0121-0046	C-VAR 9-35PF	A1	C515	5	0160-0576	C-F .1UF 20% CER
A1	C205	1	0160-4318	C-F 330PF 1%	A1	C516	5	0160-0576	C-F .1UF 20% CER
A1	C206	9	0160-2675	C-F 3900PF 300V	A1	C517	5	0160-0576	C-F .1UF 20% CER
A1	C207	4	0160-5426	C-F .039UF 1% 63V	A1	C518	5	0160-0576	C-F .1UF 20% CER
A1	C208	2	0160-5424	C-F .39UF 1% 40V	A1	C519	1	0160-3097	C-F .47UF CER
A1	C209	3	0160-3726	C-F 1UF 10% 100V	A1	C520	1	0160-3097	C-F .47UF CER
A1	C210	9	0160-3838	C-F 2.2UF 10%	A1	C521	1	0160-3097	C-F .47UF CER
A1	C211	1	0160-0572	C-F 2200PF CER	A1	C522	1	0160-3097	C-F .47UF CER
A1	C212	5	0160-0576	C-F .1UF 20% CER	A1	C523	5	0180-0582	C-F 270UF 40V
A1	C213	9	0160-0174	C-F .47UF 25VCER	A1	C524	5	0180-0582	C-F 270UF 40V
A1	C214	5	0160-0576	C-F .1UF 20% CER	A1	C525 *	0	0160-5738	C-F 6.8PF
A1	C215	5	0160-0576	C-F .1UF 20% CER	A1	C526	5	0160-0576	C-F .1UF 20% CER
A1	C216	0	0160-4383	C-F 6.8PF 200V	A1	C527 *	4	0160-4350	C-F 68PF 200V
A1	C217	2	0160-3874	C-F 10PF 200V	A1	C528	7	0160-4380	C-F 1PF 200V
A1	C220	5	0160-0576	C-F .1UF 20% CER	A1	C529	0	0121-0466	C-VAR 1-3PF 100V
A1	C221	5	0160-3878	C-F .001UF 100V	A1	C530 *	7	0160-4380	C-F 1PF 200V
A1	C222	5	0160-3878	C-F .001UF 100V	A1	C531	0	0160-3568	C-F 2.7PF 200V
A1	C223	0	0160-4383	C-F 6.8PF 200V	A1	C533	5	0160-0576	C-F .1UF 20% CER
A1	C224	5	0160-0576	C-F 1UF 20% CER	A1	C534	5	0160-0576	C-F .1UF 20% CER
A1	C225	6	0160-3878	C-F 001UF 100V	A1	C535	5	0160-0576	C-F .1UF 20% CER
					A1	C536	5	0160-0576	C-F .1UF 20% CER

Table 6-3. Replaceable Parts

REFERENCE DESIGNATOR	C D	H-P PART NUMBER	DESCRIPTION	REFERENCE DESIGNATOR	C D	H-P PART NUMBER	DESCRIPTION
A1 C537	5	0160-0576	C-F .1UF 20% CER	A1 L504	0	9170-0894	CORE MAGNETIC
A1 C538 *	8	0160-4381	C-F 1.5PF 200V	A1 L505	0	9170-0894	CORE MAGNETIC
A1 C539	6	0160-4389	C-F 100PF				
A1 C541		0160-3879	C-F .01UF 100V				
A1 C550	5	0160-0576	C-F .1UF 20% CER				
A1 CR1	3	1901-0638	DIO AY-SI 100V				
A1 CR2	7	1906-0096	DIO-FULL WAVE BR	A1 MP1		08112-21104	HEATSINK
A1 CR3	7	1906-0096	DIO-FULL WAVE BR	A1 MP2		08112-05401	PLATE INSULATOR
A1 CR4	1	1901-1098	DIO-SWIT.1N4150	A1 MP3		08112-05401	PLATE INSULATOR
A1 CR5	1	1901-1098	DIO-SWIT.1N4150	A1 MP4	6	00180-09104	CLIP-GROUND
				A1 MP100		08112-04155	BRACKET-POTI
A1 CR6	1	1901-1098	DIO-SWIT.1N4150				
A1 CR7	1	1901-1098	DIO-SWIT.1N4150	A1 MP200	0	1205-0235	HEAT SINK
A1 CR8	1	1901-1098	DIO-SWIT.1N4150	A1 MP500		08116-04151	XSTR HEATSINK
A1 CR9	1	1901-1098	DIO-SWIT.1N4150	A1 MP501	3	1205-0329	HT-SINK SGL
A1 CR101	3	1901-0539	DIO SCHOTTKY				
A1 CR151	1	1901-1098	DIO-SWIT.1N4150	A1 Q1	5	1854-0368	XSTR 2N5191
A1 CR152	1	1901-1098	DIO-SWIT.1N4150	A1 Q2	1	1854-0637	XSTR SI 2219A
A1 CR153	3	1901-0539	DIO SCHOTTKY	A1 Q3	5	1854-0368	XSTR 2N5191
A1 CR154	3	1901-0539	DIO SCHOTTKY	A1 Q4	1	1854-0637	XSTR SI 2219A
A1 CR201	1	1901-1098	DIO-SWIT.1N4150	A1 Q5	9	1853-0314	XSTR 2N2905A PNP
A1 CR202	1	1901-1098	DIO-SWIT.1N4150				
A1 CR203	3	1901-0539	DIO SCHOTTKY	A1 Q6	6	1853-0212	XSTR 2N5194 SI
A1 CR204	3	1901-0539	DIO SCHOTTKY	A1 Q100	1	1854-0215	XSTR SI 2N3904
A1 CR300	1	1901-1098	DIO-SWIT.1N4150	A1 Q101	2	1853-0036	XSTR SI 2N3906
A1 CR301	1	1901-1098	DIO-SWIT.1N4150	A1 Q102	1	1854-0215	XSTR SI 2N3904
				A1 Q200	2	1853-0036	XSTR SI 2N3906
A1 CR302	1	1901-1098	DIO-SWIT.1N4150	A1 Q201	2	1853-0036	XSTR SI 2N3906
A1 CR501	7	1901-0179	DIO SI 15V .75NS	A1 Q202	2	1853-0036	XSTR SI 2N3906
A1 CR502	7	1901-0179	DIO SI 15V .75NS	A1 Q203	7	1853-0354	XSTR MPS H81
A1 CR503	7	1901-0179	DIO SI 15V .75NS	A1 Q204	7	1853-0354	XSTR MPS H81
A1 CR504	7	1901-0179	DIO SI 15V .75NS	A1 Q205	1	1854-0215	XSTR SI 2N3904
A1 CR505	7	1901-0050	DIO SWIT. 80V 200				
A1 CR506	7	1901-0050	DIO SWIT. 80V 200	A1 Q206	1	1854-0215	XSTR SI 2N3904
A1 CR507	1	1901-1098	DIO-SWIT.1N4150	A1 Q207	1	1854-0215	XSTR SI 2N3904
A1 CR508	1	1901-1098	DIO-SWIT.1N4150	A1 Q208	1	1854-0215	XSTR SI 2N3904
A1 CR509	1	1901-1098	DIO-SWIT.1N4150	A1 Q209	1	1854-0215	XSTR SI 2N3904
				A1 Q210	1	1854-0392	XSTR SI 2N3088
A1 CR510	1	1901-1098	DIO-SWIT.1N4150				
A1 CR511	1	1901-1098	DIO-SWIT.1N4150	A1 Q211	2	1853-0036	XSTR SI 2N3906
A1 CR512	1	1901-1098	DIO-SWIT.1N4150	A1 Q212	2	1853-0036	XSTR SI 2N3906
A1 CR513		1901-0732	DIO-PWR 1KV 1A	A1 Q213	2	1853-0036	XSTR SI 2N3906
A1 CR514		1901-0732	DIO-PWR 1KV 1A	A1 Q214	2	1853-0036	XSTR SI 2N3906
A1 F1	6	2110-0297	FUSE .5A 125V	A1 Q215	2	1853-0036	XSTR SI 2N3906
A1 F2	6	2110-0297	FUSE .5A 125V				
A1 J1		1251-5184	CONN 7 PIN	A1 Q220	1	1854-0215	XSTR SI 2N3904
A1 J2	2	1251-3119	CONN 20PIN RIBN	A1 Q260	2	1854-0795	XSTR MPS-H10
A1 J3	8	1251-3305	CONN-4-PIN	A1 Q261	2	1854-0795	XSTR MPS-H10
				A1 Q262	2	1853-0218	XSTR SI PNP
A1 K201	5	0490-1137	RELAY-REED 1A	A1 Q263	2	1853-0218	XSTR SI PNP
A1 K202	5	0490-1137	RELAY-REED 1A				
A1 K501	5	0490-1137	RELAY-REED 1A	A1 Q300	1	1854-0215	XSTR SI 2N3904
A1 K502	5	0490-1137	RELAY-REED 1A	A1 Q301	1	1854-0215	XSTR SI 2N3904
A1 K503	5	0490-1137	RELAY-REED 1A	A1 Q302	1	1854-0215	XSTR SI 2N3904
				A1 Q303	1	1854-0215	XSTR SI 2N3904
A1 K504	5	0490-1137	RELAY-REED 1A	A1 Q401	9	1853-0075	XSTR SI PNP
A1 K505	5	0490-1137	RELAY-REED 1A				
A1 K506	5	0490-1137	RELAY-REED 1A	A1 Q402	2	1853-0218	XSTR SI PNP
				A1 Q403	2	1853-0036	XSTR SI 2N3906
A1 L100	0	9170-0894	CORE MAGNETIC	A1 Q430	2	1853-0036	XSTR SI 2N3906
A1 L101	0	9170-0894	CORE MAGNETIC	A1 Q431	5	1854-0392	XSTR SI 2N5088
A1 L102	0	9170-0894	CORE MAGNETIC	A1 Q432	2	1853-0086	XSTR SI 2N5087
A1 L103	0	9170-0894	CORE MAGNETIC				
A1 L260	3	9100-2254	COIL-CHOKE .39UH	A1 Q433	1	1854-0215	XSTR SI 2N3904
				A1 Q501	9	1854-0809	TRANS.2N 2369A
A1 L261	0	9170-0894	CORE MAGNETIC	A1 Q502	9	1853-0405	XSTR SI 2N4209
A1 L300	0	9170-0894	CORE MAGNETIC	A1 Q503	9	1854-0354	XSTR SI NPN
				A1 Q504	9	1853-0357	XSTR SI PNP
A1 L301	0	9170-0894	CORE MAGNETIC				
A1 L500	0	9170-0894	CORE MAGNETIC	A1 Q505	7	1853-0312	XSTR PNP 2N5160
A1 L501	0	9170-0894	CORE MAGNETIC	A1 Q506	9	1854-0784	XSTR NPN 2N3866A
A1 L502	0	9170-0894	CORE MAGNETIC	A1 Q507	7	1854-0477	XSTR NPN 2N2222A
A1 L503	0	9170-0894	CORE MAGNETIC	A1 Q508	9	1854-0784	XSTR NPN 2N3866A
				A1 Q509	7	1853-0312	XSTR PNP 2N5160

Table 6-3. Replaceable Parts

REFERENCE DESIGNATOR	C D	H-P PART NUMBER	DESCRIPTION	REFERENCE DESIGNATOR	C D	H-P PART NUMBER	DESCRIPTION
A1 Q510	9	1854-0637	XSTR 2N2219A	A1 R152	9	0757-0442	R-F 10K1% .125W
A1 Q511	7	1853-0314	XSTR 2N2905A	A1 R153	9	0757-0442	R-F 10K1% .125W
A1 Q512	9	1853-0637	XSTR 2N2219A	A1 R154	7	0757-0200	R-F 5.62K1%
A1 Q513	7	1853-0314	XSTR 2N2905A	A1 R155	8	0698-4514	R-F 105K1% .125W
A1 Q514	1	1854-0215	XSTR SI 2N3904	A1 R157	1	0698-3155	R-F 4.64K 1% .125
A1 Q515	2	1853-0036	XSTR SI 2N3906	A1 R158	5	1810-0279	R-NETWORK 4.7K
A1 Q590	1	1854-0215	XSTR SI 2N3904	A1 R200	7	0698-4422	R-F 1.27K1%
A1 Q591	1	1854-0215	XSTR SI 2N3904	A1 R201	7	0698-4422	R-F 1.27K1%
A1 R1	8	0698-3615	R-F 47 5%	A1 R202	1	1810-0332	R-NETWORK 680
A1 R2	7	0812-0111	R-F .05 3% 3W	A1 R204	5	0698-7226	R-F 383 1% .05W
A1 R3	0	0698-4508	R-F 78.7K1%	A1 R205	9	0698-7220	R-F 215 1% .05W
A1 R4	0	0698-0085	R-F 2.61K1%	A1 R206	3	0698-7216	R-F 147 1% .05W
A1 R5	6	0812-0045	R-F .15 5% 3W	A1 R207	9	1810-0281	R-NETWORK SIP
A R6	1	0757-0460	R-F 61.9K 1%	A1 R208	1	1810-0332	R-NETWORK 680
A1 R7	0	0698-0085	R-F 2.61K1%	A1 R209	8	1810-0206	R-NETWORK 7X10K
A1 R8	0	0698-0085	R-F 2.61K1%	A1 R210	4	0698-8827	R-F 1M 1% .125W
A1 R9	5	0757-0464	R-F 90.9K1%	A1 R211	4	0698-8827	R-F 1M 1% .125W
A1 R10	7	0812-0111	R-F .05 3% 3W	A1 R213	2	0698-7215	R-F 133 1% .05W
A1 R11	3	0698-4460	R-F 649 1% .125W	A1 R215	0	0698-3152	R-F 3.48K 1%
A1 R12	7	2100-3211	R-TRMR 1K 10%	A1 R216	9	0698-4367	R-F 20.5 1%
A1 R13	0	0757-0401	R-F 100 1% .125W	A1 R217	8	0698-3433	R-F 28.7 1%
A1 R14	8	0698-6320	R-F 5K 1% .125W	A1 R219	7	0757-0440	R-F 7.5K 1% .125W
A1 R15	8	0698-8863	R-F 5.2K 1%	A1 R220 *	7	0757-0281	R-F 2.74K 1%
A1 R16	9	0698-3442	R-F 237 1% .125W	A1 R221	6	2100-3252	RES-TRMR 5K 10%
A1 R17	9	0757-0434	R-F 3.65K1%	A1 R222	7	0757-0440	R-F 7.5K 1% .125W
A1 R18	7	2100-3211	R-TRMR 1K 10%	A1 R223 *	7	0757-0281	R-F 2.74K 1%
A1 R19	7	2100-3211	R-TRMR 1K 10%	A1 R224	6	2100-3252	RES-TRMR 5K 10%
A1 R20	9	0757-0434	R-F 3.65K1%	A1 R225	4	0698-3439	RES 178 1% .125W
A1 R21	9	0698-3442	R-F 237 1% .125W	A1 R226	8	0698-4429	R-F 187K 1%
A1 R22		0698-4421	R-F 249 1% .125W	A1 R227	5	2100-0554	R-V 500 10% 5W
A1 R23	2	0698-4435	R-F 2.49K1%	A1 R228	4	0698-8819	R-F 3.83 1% 1/8W
A1 R24	5	2100-0554	R-V 500 10% .5W	A1 R229	1	0757-0410	R-F 301 1% .125W
A1 R25	5	2100-0554	R-V 500 10% .5W	A1 R230	3	0757-0280	R-F 1K1% .125W F
A1 R26	2	0698-4435	R-F 2.49K1%	A1 R231	3	0757-0420	R-F 750 1% .125W
A1 R27		0698-4421	R-F 249 1% .125W	A1 R232	2	0698-6324	R-F 187 1% .125W
A1 R28	3	1810-0037	R-NETWORK DIP	A1 R233	1	0757-0410	R-F 301 1% .125W
A1 R100	8	0698-3540	R-F 15.4K1%	A1 R234	1	0757-0410	R-F 301 1% .125W
A1 R101	6	0757-0449	R-F 20K1% .125W	A1 R235	4	0698-4073	R-F 1M10% .125W
A1 R102	6	0757-0449	R-F 20K1% .125W	A1 R236	4	0698-4073	R-F 1M10% .125W
A1 R103	6	0757-0449	R-F 20K1% .125W	A1 R237	4	0698-4073	R-F 1M10% .125W
A1 R104	0	0698-3154	R-F 4.22K 1%	A1 R238	4	0698-4073	R-F 1M10% .125W
A1 R105	1	0757-0410	R-F 301 1% .125W	A1 R239	4	0698-4073	R-F 1M10% .125W
A1 R106		2100-3976	R-VAR 10K 20%	A1 R240	1	0698-3155	R-F 4.64K 1% .125
A1 R107	7	0698-3359	R-F 12.7K1%	A1 R241	3	0757-0280	R-F 1K1% .125W F
A1 R108	6	0698-4497	R-F 48.7K 1%	A1 R242	2	0698-4469	R-F 1.15K1%
A1 R109	2	0698-4435	R-F 2.49K1%	A1 R243	5	0757-0274	R-F 1.21K1%
A1 R110	0	0757-0401	R-F 100 1% .125W	A1 R244	8	0698-0083	R-F 1.96K1%
A1 R111	8	0698-3178	R-F 487 1% .125W	A1 R245	4	0757-0405	R-F 162 1% .125W
A1 R112	5	1810-0203	R-NETWORK 7X470	A1 R246	3	0698-3446	R-F 383 1% .125W
A1 R113	8	0698-3152	R-F 3.48K 1%	A1 R260	8	0698-3178	R-F 487 1% .125W
A1 R114	8	0698-3178	R-F 487 1% .125W	A1 R261	9	0698-3442	R-F 237 1% .125W
A1 R115	0	0757-0401	R-F 100 1% .125W	A1 R262	0	0757-0419	R-F 681 1% .125W
A1 R116	8	1810-0280	R-NETWORK 9X10K	A1 R263		0698-4421	R-F 249 1% .125W
A1 R117	3	1810-0243	R-NETWORK 8X6.8K	A1 R264	6	0757-0499	R-F 27.4 1% .25W
A1 R118	5	1810-0279	R-NETWORK 4.7K	A1 R265	7	0757-1000	R-F 51.1 1% .5W
A1 R119	3	0757-0280	R-F 1K1% .125W F	A1 R266	3	0757-0389	R-F 33.2 1%
A1 R120	3	0757-0420	R-F 750 1% .125W	A1 R267	6	0757-0803	R-F 182 1% .5W
A1 R121	4	0757-0439	R-F 6.81K1%	A1 R268	6	0757-0803	R-F 182 1% .5W
A1 R122	1	0757-0410	R-F 301 1% .125W	A1 R269	9	0757-1094	R-F 1.47K1%
A1 R123	4	0698-3444	R-F 316 .125W 1%	A1 R270	3	0698-4460	R-F 649 1% .125W
A1 R124	1	0698-7214	R-F 121 1% .05W				
A1 R125	8	0698-3178	R-F 487 1% .125W				
A1 R130		2100-3212	R-VAR 200 10%				
A1 R150	5	1810-0279	R-NETWORK 4.7K				
A1 R151	9	0757-0442	R-F 10K1% .125W				

Table 6-3. Replaceable Parts

REFERENCE DESIGNATOR	C D	H-P PART NUMBER	DESCRIPTION	REFERENCE DESIGNATOR	C D	H-P PART NUMBER	DESCRIPTION
A1 R271	5	0698-4404	R-F 105 1% .125W	A1 R446	6	0757-0449	R-F 20K1% .125W
A1 R272	8	0698-3433	R-F 28.7 1%	A1 R447	4	0698-8958	R-F 511K 1%
A1 R300	0	0757-0401	R-F 100 1% .125W				
A1 R301	8	0698-3178	R-F 487 1% .125W	A1 R449	9	0698-3450	R-F 42.2K 1%
A1 R302	8	0698-3178	R-F 487 1% .125W	A1 R450	0	2100-3214	R-V 100K 10% .5W
A1 R303	9	0698-3228	R-F 49.9K1%	A1 R451	3	0698-4486	R-F 24.9K1%
A1 R304	6	2100-3210	R-VAR 10K 10% .5W	A1 R452	1	0757-0460	R-F 61.9K 1%
A1 R305	Q	0757-0401	R-F 100 1% .125W	A1 R453	7	0698-4498	R-F 53.6K1%
A1 R306	1	0757-0460	R-F 61.9K 1%	A1 R501	8	0698-7196	R-F 21.5 2% .05W
A1 R307	3	0698-4486	R-F 24.9K1%	A1 R502	9	0757-0385	R-F 22.1 1%
A1 R308	3	0757-0280	R-F 1K1% .125W F	A1 R503	0	0698-4392	R-F 71.5 1/8W 1%
A1 R309*	7	0757-0401	R-F 100 .125W 1%	A1 R504	9	0757-0294	R-F 17.8 1%
A1 R310*	6	0757-0283	R-F 2K1% .125W F	A1 R505	2	0757-0346	R-F 10 1% .125W
A1 R400	8	0698-3540	R-F 15.4K1%	A1 R506	7	0698-3440	R-F 196 1% .125W
A1 R401	0	2100-3214	R-V 100K 10% .5W	A1 R507		0699-0644	R-F 7.87 1%
A1 R402	0	2100-3214	R-V 100K 10% .5W	A1 R508	3	0757-0462	R-F 75K1% .125W
A1 R403	0	2100-3214	R-V 100K 10% .5W	A1 R509		0698-4421	R-F 249 1% .125W
A1 R404	4	0698-4446	R-F 267 .125W 1%	A1 R510	7	0757-0440	R-F 7.5K 1% .125W
A1 R405	1	0757-0426	R-F 1.3K .125W 1%	A1 R511	7	0698-3359	R-F 12.7K1%
A1 R406	1	0757-0426	R-F 1.3K .125W 1%	A1 R512	7	0698-3359	R-F 12.7K1%
A1 R407	7	2100-3211	R-TRMR 1K 10%	A1 R513	5	0698-3498	R-F 8.66K1%
A1 R408	4	0698-4446	R-F 267 .125W 1%	A1 R514	3	0698-4460	R-F 649 1% .125W
A1 R409	9	2100-0558	RES-TRMR 20K 10%	A1 R515	1	2100-0568	R-VAR 100
A1 R410	7	2100-3211	R-TRMR 1K 10%	A1 R516	0	0757-0443	R-F 11K1% .125W
A1 R411	9	0757-0278	R-F 1.78K1%	A1 R517	0	0757-0443	R-F 11K1% .125W
A1 R412	9	0698-7220	R-F 215 1% .05W	A1 R518	2	0698-4386	R-F 59.0 1/8W 1%
A1 R413	9	2100-0558	RES-TRMR 20K 10%	A1 R519	2	0698-4386	R-F 59.0 1/8W 1%
A1 R414	9	2100-0558	RES-TRMR 20K 10%	A1 R520	3	0757-0280	R-F 1K1% .125W F
A1 R415	0	0698-7205	R-F 51.1 1% .05W	A1 R521	3	0757-0280	R-F 1K1% .125W F
A1 R416	9	2100-0558	RES-TRMR 20K 10%	A1 R522	3	0757-0280	R-F 1K1% .125W F
A1 R417	9	2100-0558	RES-TRMR 20K 10%	A1 R523	3	0757-0280	R-F 1K1% .125W F
A1 R418	9	2100-0558	RES-TRMR 20K 10%	A1 R524	0	0757-0401	R-F 100 1% .125W
A1 R419	1	0698-3428	R-F 14.7 1%	A1 R525	6	0757-0283	R-F 2K1% .125W F
A1 R420	1	0698-3428	R-F 14.7 1%	A1 R526	6	0757-0283	R-F 2K1% .125W F
A1 R421	0	0698-7221	R-F 237 1% .05W	A1 R527	0	0757-0401	R-F 100 1% .125W
A1 R422	1	0757-0288	R-F 9.09K 1% .125	A1 R528	2	0698-3495	R-F 866 1% .125W
A1 R423	3	0698-3438	R-F 147 1% .125W	A1 R529	2	0698-3495	R-F 866 1% .125W
A1 R424	3	0757-0280	R-F 1K1% .125W F	A1 R530	3	0757-1022	R-F 1.78K 1%
A1 R425	0	2100-0567	R-VAR 2K 10% .5W	A1 R531	3	0757-1022	R-F 1.78K 1%
A1 R426	3	0757-0280	R-F 1K1% .125W F	A1 R532	3	0757-0751	R-F 7.5K 1% .25W
A1 R427	3	0698-3438	R-F 147 1% .125W	A1 R533	2	0698-3429	R-F 19.6 1%
A1 R428*	1	0698-7264	R-F 14.7K .05W 1%	A1 R534	2	0698-3429	R-F 19.6 1%
A1 R430	3	0698-4444	R-F 4.87K1%	A1 R535	7	2100-3211	R-TRMR 1K 10%
A1 R431	3	0698-4444	R-F 4.87K1%	A1 R536	1	0698-7221	R-F 237 .05 1%
A1 R432	4	0757-0273	R-F 3.01K1%	A1 R537	2	0698-3429	R-F 19.6 1%
A1 R433	3	0698-4444	R-F 4.87K1%	A1 R538	2	0698-3429	R-F 19.6 1%
A1 R434	3	0698-4444	R-F 4.87K1%	A1 R539	7	0698-8820	R-F 4.64 1% .25W
A1 R435	3	0698-3446	R-F 383 1% .125W	A1 R540	7	0698-8820	R-F 4.64 1% .25W
A1 R436	5	0698-3258	R-F 5.36K1%	A1 R541	2	0698-3495	R-F 866 1% .125W
A1 R437	0	0698-4425	R-F 1.54K1%	A1 R542	2	0698-3495	R-F 866 1% .125W
A1 R438	1	0698-3155	R-F 4.64K 1% .125	A1 R543	2	0757-0346	R-F 10 1% .125W
A1 R439*	4	0757-0444	R-F 12.1K 1%	A1 R544	2	0757-0346	R-F 10 1% .125W
A1 R440	0	0757-0419	R-F 681 1% .125W	A1 R545	2	0757-0346	R-F 10 1% .125W
A1 R441	7	0698-3432	R-F 26.1 1%	A1 R546	2	0757-0346	R-F 10 1% .125W
A1 R445	9	2100-3214	R-VAR 100K 10%	A1 R547	3	0766-0025	R-F 101 2% 3W MO
				A1 R548	3	0766-0025	R-F 101 2% 3W MO
				A1 R549	3	0757-0818	R-F 825 1% .5W
				A1 R550	1	0698-4864	R-F 499 1% .5W
				A1 R551	8	0757-1001	R-F 56.2 1% .5W
				A1 R552	3	0757-0280	R-F 1K1% .125W F
				A1 R553	8	0698-8369	R-F 2.7 .125W 5%
				A1 R554	9	0698-4367	R-F 20.5 1%
				A1 R555	9	0698-4367	R-F 20.5 1%

Table 6-3. Replaceable Parts

REFERENCE DESIGNATOR	C D	H-P PART NUMBER	DESCRIPTION	REFERENCE DESIGNATOR	C D	H-P PART NUMBER	DESCRIPTION
A1		08116-66511	BD AY-MAIN	A2		08116-66502	BD AY-CONTROL
A1 R556 *	0	0698-7195	R-F 19.6	A2 C1	9	0160-3839	C-F 2.2UF 10%
A1 R558 *	4	0698-7209	R-F 75 1% .05W	A2 C2	6	0160-3878	C-F .001UF 100V
A1 R559	5	0757-0399	R-F 82.5 1%	A2 C4	0	0180-2856	C-F 47UF 10% 25V
A1 R560	5	0757-0399	R-F 82.5 1%	A2 C5	5	0160-0576	C-F .1UF 20% CER
A1 R561		0757-0279	R-F 3.16K .125W 1%	A2 C7	3	0160-4386	C-F 33PF 5% 200V
A1 R590	1	0757-0460	R-F 61.9K 1%	A2 C8	3	0160-4386	C-F 33PF 5% 200V
A1 R591	7	0698-3226	R-F 6.49K1%	A2 C9	7	0160-3879	C-F .01UF 100V
A1 R592	9	0757-0442	R-F 10K1% .125W	A2 C10	0	0180-2856	C-F 47UF 10% 25V
A1 S1	2	3101-2091	SWITCH PUSHBUT	A2 C11	0	0180-2856	C-F 47UF 10% 25V
				A2 C12	7	0160-3879	C-F .01UF 100V
A1 U1	3	1826-0315	IC LM348				
A1 U2	3	1826-0315	IC LM348	A2 C14	7	0160-3879	C-F .01UF 100V
A1 U3	7	1826-0393	IC-LINEAR LM317T	A2 C15	3	0160-3718	C-F .047 UF 250V
A1 U4	9	1826-0527	IC LM337T	A2 C16	0	0180-2856	C-F 47UF 10% 25V
A1 U5	7	1826-0393	IC-LINEAR LM317T	A2 C17	5	0160-0576	C-F .1UF 20% CER
				A2 C18	5	0160-0576	C-F .1UF 20% CER
A1 U6	9	1826-0527	IC LM337T				
A1 U100	1	1820-0810	IC MC 10116	A2 C19	5	0160-0576	C-F .1UF 20% CER
A1 U101	0	1826-0346	IC LM358N	A2 C23	5	0160-0576	C-F .1UF 20% CER
				A2 C26	5	0160-0576	C-F .1UF 20% CER
A1 U102	1	1820-0802	IC-ECL 10102	A2 C29	5	0160-0576	C-F .1UF 20% CER
A1 U103	6	1820-1730	IC OCTFF74LS273				
A1 U104	5	1820-1359	IC MC10174P MUXR	A2 CR1	1	1901-1098	DIO-SWIT .1N4150
A1 U110	3	1820-1216	IC-SN74LS138	A2 CR2	1	1901-1098	DIO-SWIT .1N4150
A1 U150	6	1820-1730	IC OCTFF74LS273	A2 CR3	1	1901-1098	DIO-SWIT .1N4150
				A2 CR4	1	1901-1098	DIO-SWIT .1N4150
A1 U151	0	1826-0207	IC LM 318 OP AMP	A2 CR7	9	1901-0535	DIO SCHOTTKY
A1 U152	2	1820-1546	IC-4052B				
A1 U200	9	1826-0753	IC 3400 4B	A2 CR8	9	1901-0535	DIO SCHOTTKY
A1 U201		1826-0955	IC SLOPE GEN	A2 CR9	9	1901-0535	DIO SCHOTTKY
A1 U202	7	1826-0111	IC-DUAL OP AMPL	A2 CR10	9	1901-0535	DIO SCHOTTKY
				A2 CR11	9	1901-0535	DIO SCHOTTKY
A1 U203	4	1820-1225	IC DGTL FLIPFLOP	A2 CR12	9	1901-0535	DIO SCHOTTKY
A1 U204	9	1826-0501	IC-CMOS 4053B				
A1 U205	2	1820-1546	IC-4052B	A2 J4	2	1251-3119	CONN 20PIN RIBN
A1 U210	7	1820-1997	IC SN74LS374CP	A2 J5	2	1251-3119	CONN 20PIN RIBN
A1 U300		5180-2410	IC TIMING SEL				
A1 U301	9	1820-1212	IC SN74LS112	A2 K1	5	0490-1137	RELAY-REED 1A
A1 U302	6	1820-1491	IC-SN74LS367N	A2 K2	5	0490-1137	RELAY-REED 1A
A1 U400	2	1820-1546	IC-4052B	A2 K3	5	0490-1137	RELAY-REED 1A
A1 U401		1826-0923	SHAPER SEL TEMP	A2 K4	5	0490-1137	RELAY-REED 1A
A1 U501	9	1826-0635	IC 714				
				A2 Q1	1	1854-0215	XSTR SI 2N3904
A1 U502	9	1826-0635	IC 714	A2 Q2	2	1853-0036	XSTR SI 2N3906
A1 U503	7	1820-1997	IC SN74LS374CP	A2 Q3	2	1854-0472	XSTR SI MPS A14
				A2 Q4	2	1854-0472	XSTR SI MPS A14
A1 VR1	7	1902-0680	DIO 6.2V 5% .25W	A2 Q5	2	1853-0036	XSTR SI 2N3906
A1 VR200	7	1902-0680	DIO 6.2V 5% .25W				
A1 VR501	0	1902-3182	DIO 12.1V 5% .4W	A2 R1	7	0757-0200	R-F 5.62K1%
A1 VR502	0	1902-3182	DIO 12.1V 5% .4W	A2 R2	5	2100-0554	R-V 500 10% .5W
				A2 R3	3	0757-0420	R-F 750 1% .125W
A1 W2	0	8159-0005	JUMPER	A2 R4	6	2100-3210	R-VAR 10K 10% .5W
A1 W3	0	8159-0005	JUMPER	A2 R6	5	0698-4123	R-F 499 1% .125W
A1 W4	0	8159-0005	JUMPER				
				A2 R7	3	0698-4014	R-F 787 1% .125W
A1 W5	0	8159-0005	JUMPER	A2 R8	6	0757-0283	R-F 2K1% .125W F
A1 W7		5180-2401	CBL RBN 150 MM	A2 R9	6	0757-0449	R-F 20K1% .125W
A1 W8		08116-61605	CABLE ASSY. SIG.O/P	A2 R10	5	0757-0472	R-F 200K1% .125W
A1 W9		08116-61607	CABLE ASSY. TRIG." "	A2 R11	4	0698-8827	R-F 1M 1% .125W
A1 W10		08116-61609	CABLE ASSY. TRIG.I/P				
				A2 R12	4	0698-8827	R-F 1M 1% .125W
A1 W11		08116-61608	CABLE ASSY. CNTRJ/P	A2 R14	5	0698-3258	R-F 5.36K1%
				A2 R15	3	0698-4014	R-F 787 1% .125W
				A2 R16	1	1810-0316	R-NETWORK 8x10K
				A2 R17	0	2100-3214	R-V 100K 10% .5W
				A2 R18	0	2100-3214	R-V 100K 10% .5W
				A2 R19	1	0757-0428	R-F 1.62K 1%

Table 6-3. Replaceable Parts

REFERENCE DESIGNATOR	C	D	H-P PART NUMBER	DESCRIPTION	REFERENCE DESIGNATOR	C	D	H-P PART NUMBER	DESCRIPTION
A2 R20	3		0698-3446	R-F 383 1% .125W	A2 VR1	4		1902-0786	DIO-ZNR 9V 5% .5W
A2 R21			1810-0470	R-NETWORK 8X2.2K	A2 VR2	7		1902-0949	DIO-ZNR 4.3V
A2 R22	0		2100-3214	R-V 100K 10% .5W					
A2 R23			0757-0476	R-F 301K 1% .125	A2 W1	0		8159-0005	JUMPER
A2 R24	5		2100-0554	R-V 500 10% .5W	A2 W2	0		8159-0005	JUMPER
A2 R25	0		2100-3214	R-V 100K 10% .5W					
A2 R26			0757-0476	R-F 301K 1% .125					
A2 R27	5		2100-0554	R-V 500 10% .5W	A3			08116-66503	BD AY-MICROPRCR
A2 R28	1		0698-4442	R-F 4.42K1%					
A2 R29	8		0757-0417	R-F 562 1% .125W	A3 BT1	6		1420-0251	BATTERY-NICAD
A2 R30	9		0698-3152	R-F 3.48 K	A3 C1	3		0160-4493	C-F 27PF 5% 200V
A2 R31	0		2100-0567	R-VAR 2K 10% .5W	A3 C2	3		0160-4493	C-F 27PF 5% 200V
A2 R32	0		2100-0567	R-VAR 2K 10% .5W	A3 C3	5		0160-0576	C-F .1UF 20% CER
A2 R33	3		0757-0458	R-F 51.1K	A3 C4	5		0160-0576	C-F .1UF 20% CER
A2 R35	0		0757-0401	R-F 100 1% .125W	A3 C5	5		0160-0576	C-F .1UF 20% CER
A2 R36	0		0757-0401	R-F 100 1% .125W	A3 C6	0		0180-2856	C-F 47UF 10% 25V
A2 R41	6		0698-6360	R-F 10K 1% .125W	A3 C7	5		0180-2207	C-F 100UF 10V
A2 R42	6		0698-6360	R-F 10K 1% .125W	A3 C8	0		0180-2856	C-F 47UF 10% 25V
A2 R43	0		2100-3252	R-TRMR 5%	A3 C9	5		0160-0576	C-F .1UF 20% CER
A2 R44	6		0757-0465	R-F 100K1% .125W	A3 C11	5		0160-0576	C-F .1UF 20% CER
A2 R45	1		0698-3155	R-F 4.64K 1% .125	A3 C12	5		0160-0576	C-F .1UF 20% CER
A2 R46	6		0757-0465	R-F 100K1% .125W	A3 C13	5		0160-0576	C-F .1UF 20% CER
A2 R47	3		0698-4486	R-F 24.9K1%	A3 C14	5		0160-0576	C-F .1UF 20% CER
A2 R48	4		0698-4487	R-F 25.5K 1%	A3 C15	5		0160-0576	C-F .1UF 20% CER
A2 R50	8		1810-0206	R-NETWORK 7X10K	A3 C16	5		0160-0576	C-F .1UF 20% CER
A2 R51	3		0757-0280	R-F 1K1% .125W F	A3 C17	5		0160-0576	C-F .1UF 20% CER
A2 R52	1		0698-3452	R-F 147K1% .125W	A3 C18	5		0160-0576	C-F .1UF 20% CER
A2 R54	8		0757-0277	R-F 49.9 1%	A3 C19	5		0160-0576	C-F .1UF 20% CER
A2 R55	1		0698-3444	R-F 316 1% .125W	A3 C20	5		0160-0576	C-F .1UF 20% CER
A2 R56	2		0698-6324	R-F 187 1% .125W	A3 C21	5		0160-0576	C-F .1UF 20% CER
A2 U1	9		1826-0519	IC TL071CC	A3 C22	5		0160-0576	C-F .1UF 20% CER
A2 U2	9		1826-0519	IC TL071CC	A3 C23	5		0160-0576	C-F .1UF 20% CER
A2 U3	2		1820-1885	IC-SN74LS173	A3 C24	5		0160-0576	C-F .1UF 20% CER
A2 U4	5		1826-0276	IC 78L05 V RGLTR	A3 C25	5		0160-0576	C-F .1UF 20% CER
A2 U5	9		1826-0753	IC 3400 4B	A3 C26	5		0160-0576	C-F .1UF 20% CER
A2 U6	3		1826-0729	IC-CONV 7522JN	A3 C27	5		0160-0576	C-F .1UF 20% CER
A2 U7	9		1826-0635	IC 714	A3 C28	5		0160-0576	C-F .1UF 20% CER
A2 U8	4		1826-0639	IC-7524JN	A3 C29	5		0160-3877	C-F 100PF 200V
A2 U9	9		1826-0635	IC 714	A3 C30	5		0160-0576	C-F .1UF 20% CER
A2 U10	4		1826-0639	IC-7524JN	A3 C31	5		0160-0576	C-F .1UF 20% CER
A2 U11	9		1826-0635	IC 714	A3 C32	5		0160-0576	C-F .1UF 20% CER
A2 U12	3		1826-0521	IC-TL 072CP	A3 C33	5		0160-0576	C-F .1UF 20% CER
A2 U13	3		1826-0729	IC-CONV 7522JN	A3 C34	5		0160-0576	C-F .1UF 20% CER
A2 U14	3		1820-1216	IC-SN74LS138	A3 C36	5		0160-0576	C-F 1UF 20% CER
A2 U15	6		1820-1730	IC OCTFF74LS273	A3 CR1	9		1901-0535	DIO SCHOTTKY
A2 U16	9		1826-0501	IC-CMOS 4053B	A3 CR2	9		1901-0535	DIO SCHOTTKY
A2 U17	9		1826-0501	IC-CMOS 4053B	A3 CR3	1		1901-1098	DIO-SWIT.1N4150
A2 U19	1		1820-1199	IC SN74LS 04	A3 CR4	1		1901-1098	DIO-SWIT.1N4150
A2 U20	3		1820-1216	IC-SN74LS138	A3 J1	0		1251-3141	CONN 50PIN RIBN
A2 U21	6		1820-1730	IC OCTFF74LS273	A3 J2	8		1251-0541	CONN 34PIN RIBN
A2 U22	6		1820-1730	IC OCTFF74LS273	A3 J3	0		1251-3167	CONNECTOR 4 PIN
A2 U23	6		1820-1730	IC OCTFF74LS273	A3 MP1	7		1400-0824	CABLE STRAP
A2 U24	9		1826-0697	IC CONV 18-DIP-P	A3 P1	5		1258-0124	PIN PROG JUMPER
A2 U25	9		1826-0635	IC 714	A3 Q1	9		1853-0281	XSTR SI 2907A
A2 U26	9		1826-0635	IC 714	A3 R1	8		1810-0280	R-NETWORK 9X10K
A2 U27	3		1826-0729	IC-CONV 7522JN	A3 R2	7		0698-8812	R-F 1 1% .125W
A2 U28	3		1826-0521	IC-TL 072CP	A3 R3	3		1810-0277	R-NETWORK 9X2.2K
A2 U31	0		1826-0180	IC TIMER NE555E	A3 R4	7		1810-0338	R-NETWORK 8X100
A2 U40	9		1820-1197	IC SN74LS00	A3 R5	7		1810-0338	R-NETWORK 8X100
A2 U43	6		1820-1730	IC OCTFF74LS273					

Table 6-3. Replaceable Parts

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Table 6-3. Replaceable Parts

REFERENCE DESIGNATOR		C D	H-P PART NUMBER	DESCRIPTION
A5			08116-66505	BD AY DISPLAY
A5	DS1	6	1990-0486	LED-VISIBLE RED
A5	DS4		1990-0806	LED HLMP-2300RED
A5	DS5	5	1990-0774	LED HLMP 2600
A5	DS6	5	1990-0774	LED HLMP 2600
A5	DS7	5	1990-0774	LED HLMP 2600
A5	DS15	6	1990-0486	LED-VISIBLE RED
A5	DS16	6	1990-0486	LED-VISIBLE RED
A5	DS17	6	1990-0486	LED-VISIBLE RED
A5	DS18		1990-0806	LED HLMP-2300RED
A5	DS19	6	1990-0486	LED-VISIBLE RED
A5	DS20	6	1990-0486	LED-VISIBLE RED
A5	DS21	6	1990-0486	LED-VISIBLE RED
A5	DS22	6	1990-0486	LED-VISIBLE RED
A5	DS23	6	1990-0486	LED-VISIBLE RED
A5	DS24	6	1990-0486	LED-VISIBLE RED
A5	DS25	6	1990-0486	LED-VISIBLE RED
A5	DS26	6	1990-0486	LED-VISIBLE RED
A5	DS27	6	1990-0486	LED-VISIBLE RED
A5	DS28	6	1990-0486	LED-VISIBLE RED
A5	DS33	6	1990-0486	LED-VISIBLE RED
A5	DS34	6	1990-0486	LED-VISIBLE RED
A5	DS35	6	1990-0486	LED-VISIBLE RED
A5	DS36	6	1990-0486	LED-VISIBLE RED
A5	DS37	6	1990-0486	LED-VISIBLE RED
A5	DS38	6	1990-0486	LED-VISIBLE RED
A5	DS40	6	1990-0486	LED-VISIBLE RED
A5	DS41	2	1990-0846	DISPLAY SOLID ST
A5	DS42	2	1990-0846	DISPLAY SOLID ST
A5	DS43	2	1990-0846	DISPLAY SOLID ST
A5	DS44	2	1990-0846	DISPLAY SOLID ST
A5	J1		1251-7431	CONN POST 20M
A5	J2		1251-7431	CONN POST 20M
A5	S1		3101-2529	SW RPR
A5	S2		3101-2529	SW RPR
A5	S3		3101-2529	SW RPR
A5	S4		3101-2529	SW RPR
A6			08116-66506	BD AY HPIB
A6	S1	1	3101-1860	SW AY-SL
A6	J1		1251-3283	CONN R&P MICRO
A6	W2		5180-2404	CABLE RBN 300 N.N.

Table 6-3. Replaceable Parts

REFERENCE DESIGNATOR		C	H-P PART NUMBER	DESCRIPTION	REFERENCE DESIGNATOR		C	H-P PART NUMBER	DESCRIPTION
FRAME					A2	CR16	1	1901-1098	DIO-SWIT.1N4150
					A2	CR17	1	1901-1098	DIO-SWIT.1N4150
					A2	F1	1	2110-0343	FUSE 250A 125V
					A2	F2	1	2110-0343	FUSE 250A 125V
					A2	J4	2	1251-3119	CONN 20PIN RIBN
					A2	J5	2	1251-3119	CONN 20PIN RIBN
					A2	K1	5	0490-1137	RELAY-REED 1A
					A2	K2	5	0490-1137	RELAY-REED 1A
A2				A2	K3	5	0490-1137	RELAY-REED 1A	
A2				K4	5	0490-1137	RELAY-REED 1A		
A2				L1	0	9170-0894	CORE MAGNETIC		
A2				A2	L2	0	9170-0894	CORE MAGNETIC	
A2				Q1	1	1854-0215	XSTR SI 2N3904		
A2				Q2	2	1853-0036	XSTR SI 2N3906		
A2				A2	Q3	2	1854-0472	XSTR SI MPS A14	
A2				Q4	2	1854-0472	XSTR SI MPS A14		
A2				Q5	2	1853-0036	XSTR SI 2N3906		
A2				A2	Q6	1	1854-0215	XSTR SI 2N3904	
A2				Q7	2	1853-0036	XSTR SI 2N3906		
A2	C1	9	0160-3839	C-F 2.2UF 10%	A2	R1	7	0757-0200	R-F 5.62K1%
A2	C2	6	0160-3878	C-F .001UF 100V	A2	R2	5	2100-0554	R-V 500 10% .5W
A2	C4	0	0180-2856	C-F 47UF 10% 25V	A2	R3	3	0757-0420	R-F 750 1% .125W
A2	C5	5	0160-0576	C-F .1UF 20% CER	A2	R4	6	2100-3210	R-VAR 10K 10% .5W
A2	C7	3	0160-4386	C-F 33PF 5% 200V	A2	R6	5	0698-4123	R-F 499 1% .125W
A2	C8	3	0160-4386	C-F 33PF 5% 200V	A2	R7	3	0698-4014	R-F 787 1% .125W
A2	C9	7	0160-3879	C-F .01UF 100V	A2	R8	6	0757-0283	R-F 2K1% .125W F
A2	C10	0	0180-2856	C-F 47UF 10% 25V	A2	R9	6	0757-0449	R-F 20K1% .125W
A2	C11	0	0180-2856	C-F 47UF 10% 25V	A2	R10	5	0757-0472	R-F 200K1% .125W
A2	C12	7	0160-3879	C-F .01UF 100V	A2	R11	4	0698-8827	R-F 1M 1% .125W
A2	C13	5	0160-3877	C-F 100PF 200V	A2	R12	4	0698-8827	R-F 1M 1% .125W
A2	C14	7	0160-3879	C-F .01UF 100V	A2	R13	1	0698-3444	R-F 316 1% .125W
A2	C15	3	0160-3718	C-F .047 UF 250V	A2	R14	5	0698-3258	R-F 5.36K1%
A2	C16	0	0180-2856	C-F 47UF 10% 25V	A2	R15	3	0698-4014	R-F 787 1% .125W
A2	C17	5	0160-0576	C-F .1UF 20% CER	A2	R16	1	1810-0316	R-NETWORK 8X10K
A2	C18	5	0160-0576	C-F .1UF 20% CER	A2	R17	0	2100-3214	R-V 100K 10% .5W
A2	C19	5	0160-0576	C-F .1UF 20% CER	A2	R18	0	2100-3214	R-V 100K 10% .5W
A2	C20	5	0160-3877	C-F 100PF 200V	A2	R19	1	0757-0428	R-F 1.62K 1%
A2	C21	3	0160-4386	C-F 33PF 5% 200V	A2	R20	3	0698-3446	R-F 383 1% .125W
A2	C22	5	0160-0576	C-F .1UF 20% CER	A2	R21		1810-0470	R-NETWORK 8X2.2K
A2	C23	5	0160-0576	C-F .1UF 20% CER	A2	R22	0	2100-3214	R-V 100K 10% .5W
A2	C24	5	0160-0576	C-F .1UF 20% CER	A2	R23		0757-0476	R-F 301K 1% .125
A2	C25	5	0160-0576	C-F .1UF 20% CER	A2	R24	5	2100-0554	R-V 500 10% .5W
A2	C26	5	0160-0576	C-F .1UF 20% CER	A2	R25	0	2100-3214	R-V 100K 10% .5W
A2	C27	5	0160-0576	C-F .1UF 20% CER	A2	R26		0757-0476	R-F 301K 1% .125
A2	C28	5	0160-0576	C-F .1UF 20% CER	A2	R27	5	2100-0554	R-V 500 10% .5W
A2	C29	5	0160-0576	C-F .1UF 20% CER	A2	R28	1	0698-4442	R-F 4.42K1%
A2	C30	5	0160-0576	C-F .1UF 20% CER	A2	R29	8	0757-0417	R-F 562 1% .125W
A2	C31	5	0160-0576	C-F .1UF 20% CER	A2	R30	9	0698-3153	R-F 3.83K1%
A2	CR1	1	1901-1098	DIO-SWIT.1N4150	A2	R31	0	2100-0567	R-VAR 2K 10% .5W
A2	CR2	1	1901-1098	DIO-SWIT.1N4150	A2	R32	0	2100-0567	R-VAR 2K 10% .5W
A2	CR3	1	1901-1098	DIO-SWIT.1N4150	A2	R33	3	0698-4444	R-F 4.87K1%
A2	CR4	1	1901-1098	DIO-SWIT.1N4150	A2	R35	0	0757-0401	R-F 100 1% .125W
A2	CR5	1	1901-1098	DIO-SWIT.1N4150	A2	R36	0	0757-0401	R-F 100 1% .125W
A2	CR6	1	1901-1098	DIO-SWIT.1N4150	A2	R37	9	0757-0442	R-F 10K1% .125W
A2	CR7	9	1901-0535	DIO SCHOTTKY	A2	R38	9	0698-4424	R-F 1.4K1% .125W
A2	CR8	9	1901-0535	DIO SCHOTTKY	A2	R39	9	0757-0442	R-F 10K1% .125W
A2	CR9	9	1901-0535	DIO SCHOTTKY	A2	R40	3	0757-0280	R-F 1K1% .125W F
A2	CR10	9	1901-0535	DIO SCHOTTKY	A2	R41	6	0698-6360	R-F 10K.1% .125W
A2	CR11	9	1901-0535	DIO SCHOTTKY	A2	R42	6	0698-6360	R-F 10K.1% .125W
A2	CR12	9	1901-0535	DIO SCHOTTKY	A2	R43	0	2100-0567	R-VAR 2K 10% .5W
A2	CR13	9	1901-0535	DIO SCHOTTKY	A2	R44	6	0757-0465	R-F 100K1% .125W
A2	CR14	1	1901-1098	DIO-SWIT 1N4150					
A2	CR15	1	1901-1098	DIO-SWIT 1N4150					

Table 6-3. Replaceable Parts

REFERENCE DESIGNATOR	C	D	H-P PART NUMBER	DESCRIPTION	REFERENCE DESIGNATOR	C	D	H-P PART NUMBER	DESCRIPTION
A2 R45	1		0698-3155	R-F 4.64K 1% .125	A2 U41	7		1820-1278	IC 74LS 191
A2 R46	6		0757-0465	R-F 100K1% .125W	A2 U42	7		1820-1278	IC 74LS 191
A2 R47	3		0698-4486	R-F 24.9K1%	A2 U43	6		1820-1730	IC OCTFF74LS273
A2 R48	4		0698-4487	R-F 25.5K 1%	A2 VR1	4		1902-0786	DIO-ZNR 9V 5% .5W
A2 R50	8		1810-0206	R-NETWORK 7X10K	A2 VR2	7		1902-0949	DIO ZNR 4.3V
A2 R51	3		0757-0280	R-F 1K1% .125W F	A2 W2	0		8159-0005	JUMPER
A2 R52	1		0698-3452	R-F 147K1% .125W	A2 W3	0		8159-0005	JUMPER
A2 R54	8		0757-0277	R-F 49.9 1%					
A2 R55	1		0698-3444	R-F 316 1% .125W					
A2 R56	2		0698-6324	R-F 187 1% .125W					
A2 R57	3		0757-0280	R-F 1K1% .125W F	A4			08116-66514	BD AY-KEY OPT
A2 R58	3		0757-0280	R-F 1K1% .125W F	A4 DS1	3		1990-0665	LAMP-SOLID STATE
A2 R59	3		1810-0243	R-NETWORK 8X6.8K	A4 DS2	3		1990-0665	LAMP-SOLID STATE
A2 R60	7		1810-0205	R-NETWORK 7X4.7K	A4 DS3	3		1990-0665	LAMP-SOLID STATE
A2 R61	8		1810-0206	R-NETWORK 7X10K	A4 DS4	3		1990-0665	LAMP-SOLID STATE
					A4 DS5	3		1990-0665	LAMP-SOLID STATE
A2 R62	5		1810-0203	R-NETWORK 7X470	A4 DS6	3		1990-0665	LAMP-SOLID STATE
A2 R63	5		1810-0203	R-NETWORK 7X470	A4 DS7	3		1990-0665	LAMP-SOLID STATE
A2 R64	5		1810-0203	R-NETWORK 7X470	A4 DS8	3		1990-0665	LAMP-SOLID STATE
A2 R65	8		0698-3441	R-F 215 1% .125W	A4 DS9	3		1990-0665	LAMP-SOLID STATE
A2 R66	1		0757-0428	R-F 1.62K 1%	A4 DS10	3		1990-0665	LAMP-SOLID STATE
A2 R67	1		0757-0428	R-F 1.62K 1%	A4 DS11	3		1990-0665	LAMP-SOLID STATE
					A4 DS12	3		1990-0665	LAMP-SOLID STATE
A2 U1	9		1826-0519	IC TL071CC	A4 DS13	3		1990-0665	LAMP-SOLID STATE
A2 U2	9		1826-0519	IC TL071CC	A4 DS14	3		1990-0665	LAMP-SOLID STATE
A2 U3	2		1820-1885	IC-SN74LS173	A4 DS15	3		1990-0665	LAMP-SOLID STATE
A2 U4	5		1826-0276	IC 78L05 V RGLTR	A4 DS16	3		1990-0665	LAMP-SOLID STATE
A2 U5	8		1826-0753	IC-TL 074 ACN	A4 DS17	3		1990-0665	LAMP-SOLID STATE
					A4 DS18	3		1990-0665	LAMP-SOLID STATE
A2 U6	3		1826-0729	IC-CONV 7522JN	A4 J1			1251-6255	CONN-POST 20F
A2 U7	9		1826-0635	IC 714	A4 J2			1251-6255	CONN-POST 20F
A2 U8	4		1826-0639	IC-7524JN	A4 MP1	5		5041-0309	CAP KEY QUARTER
A2 U9	9		1826-0635	IC 714	A4 MP2	5		5041-0309	CAP KEY QUARTER
A2 U10	4		1826-0639	IC-7524JN	A4 MP3	5		5041-0309	CAP KEY QUARTER
A2 U11	9		1826-0635	IC 714	A4 MP4	7		5041-0351	KEY-CAP SRF-G LT
A2 U12	3		1826-0521	IC-TL 072CP	A4 MP5	7		5041-0351	KEY-CAP SRF-G LT
A2 U13	3		1826-0729	IC-CONV 7522JN					
A2 U14	3		1820-1216	IC-SN74LS138	A4 MP6	7		5041-0351	KEY-CAP SRF-G LT
A2 U15	6		1820-1730	IC OCTFF74LS273	A4 MP7	0		5041-0726	KEY CAP LCL
A2 U16	9		1826-0501	IC-CMOS 4053B	A4 2MP8	6		5041-0285	KEY-CAP PRL-G LT
A2 U17	9		1826-0501	IC-CMOS 4053B	A4 2MP9	6		5041-0285	KEY-CAP PRL-G LT
A2 U18	6		1820-1730	IC OCTFF74LS273					
A2 U19	1		1820-1199	IC SN74LS 04	A4 2MP10	6		5041-0285	KEY-CAP PRL-G LT
A2 U20	3		1820-1216	IC-SN74LS138	A4 MP11	5		5041-0276	KEY-CAP PRL-G LT
					A4 MP12	5		5041-0276	KEY-CAP PRL-G LT
A2 U21	6		1820-1730	IC OCTFF74LS273	A4 MP13	7		5041-0351	KEY-CAP SRF-G LT
A2 U22	6		1820-1730	IC OCTFF74LS273	A4 MP14	7		5041-0351	KEY-CAP SRF-G LT
A2 U23	6		1820-1730	IC OCTFF74LS273					
A2 U24	9		1826-0697	IC CONV 18-DIP-P	A4 2MP15	6		5041-0285	KEY-CAP PRL-G LT
A2 U25	9		1826-0635	IC 714	A4 2MP16	6		5041-0285	KEY-CAP PRL-G LT
A2 U26	9		1826-0635	IC 714	A4 2MP17	6		5041-0285	KEY-CAP PRL-G LT
A2 U27	3		1826-0729	IC-CONV 7522JN	A4 MP18	7		5041-0351	KEY-CAP SRF-G LT
A2 U28	3		1826-0521	IC-TL 072CP	A4 MP19	7		5041-0351	KEY-CAP SRF-G LT
A2 U29	3		1826-0729	IC-CONV 7522JN					
A2 U30	3		1826-0521	IC-TL 072CP	A4 2MP20	6		5041-0285	KEY-CAP PRL-G LT
					A4 MP21	6		5041-0285	KEY-CAP PRL-G LT
A2 U31	0		1826-0180	IC TIMER NE555E	A4 MP22	6		5041-0285	KEY-CAP PRL-G LT
A2 U32	0		1820-0801	IC DCTL MC 10101	A4 MP23	6		5041-0285	KEY-CAP PRL-G LT
A2 U33	7		1820-1400	IC MC10104P	A4 MP24	6		5041-0285	KEY-CAP PRL-G LT
A2 U34	7		1820-1400	IC MC10104P					
A2 U35	3		1820-0820	IC MC10135L	A4 S1	7		5060-9436	SW P-BTN SINGLE
A2 U36	3		1820-0820	IC MC10135L	A4 S2	7		5060-9436	SW P-BTN SINGLE
A2 U37	1		1820-1686	IC MC 10103	A4 S3	7		5060-9436	SW P-BTN SINGLE
A2 U38	5		1820-1052	IC DCTL MC 10125	A4 S4	7		5060-9436	SW P-BTN SINGLE
A2 U39	3		1820-1282	IC 74LS109 TTL	A4 S5	7		5060-9436	SW P-BTN SINGLE
A2 U40	9		1820-1197	IC SN74LS00	A4 S6	7		5060-9436	SW P-BTN SINGLE
					A4 S7	7		5060-9436	SW P-BTN SINGLE
					A4 S8	7		5060-9436	SW P-BTN SINGLE

Table 6-3. Replaceable Parts

REFERENCE DESIGNATOR		C	H-P PART NUMBER	DESCRIPTION	REFERENCE DESIGNATOR		C	H-P PART NUMBER	DESCRIPTION
A4	S9	7	5060-9436	SW P-BTN SINGLE	A5	S1		3101-2529	SW RPR
A4	S10	7	5060-9436	SW P-BTN SINGLE	A5	S2		3101-2529	SW RPR
A4	S11	7	5060-9436	SW P-BTN SINGLE	A5	S3		3101-2529	SW RPR
A4	S12	7	5060-9436	SW P-BTN SINGLE	A5	S4		3101-2529	SW RPR
A4	S13	7	5060-9436	SW P-BTN SINGLE					
A4	S14	7	5060-9436	SW P-BTN SINGLE					
A4	S15	7	5060-9436	SW P-BTN SINGLE					
A4	S16	7	5060-9436	SW P-BTN SINGLE					
A4	S17	7	5060-9436	SW P-BTN SINGLE					
A4	S18	7	5060-9436	SW P-BTN SINGLE					
A4	S19	7	5060-9436	SW P-BTN SINGLE					
A4	S20	7	5060-9436	SW P-BTN SINGLE					
A4	S21	7	5060-9436	SW P-BTN SINGLE					
A4	S22	7	5060-9436	SW P-BTN SINGLE					
A4	S23	7	5060-9436	SW P-BTN SINGLE					
A4	S24	7	5060-9436	SW P-BTN SINGLE					
A4	W1	8	5180-2403	CBL RBN 260 MM					
A5			08116-66515	BD AY-DISPL OPT					
A5	DS1	6	1990-0486	LED-VISIBLE RED					
A5	DS2	5	1990-0774	LED HLMP 2600					
A5	DS3	5	1990-0774	LED HLMP 2600					
A5	DS4	5	1990-0774	LED HLMP 2600					
A5	DS5	5	1990-0774	LED HLMP 2600					
A5	DS6	5	1990-0774	LED HLMP 2600					
A5	DS7	5	1990-0774	LED HLMP 2600					
A5	DS8		1990-0806	LED HLMP-2300RED					
A5	DS15	6	1990-0486	LED-VISIBLE RED					
A5	DS16	6	1990-0486	LED-VISIBLE RED					
A5	DS17		1990-0486	LED-VISIBLE RED					
A5	DS18		1990-0806	LED HLMP-2300RED					
A5	DS19	6	1990-0486	LED-VISIBLE RED					
A5	DS20	6	1990-0486	LED-VISIBLE RED					
A5	DS21	6	1990-0486	LED-VISIBLE RED					
A5	DS22	6	1990-0486	LED-VISIBLE RED					
A5	DS23	6	1990-0486	LED-VISIBLE RED					
A5	DS24	6	1990-0486	LED-VISIBLE RED					
A5	DS25	6	1990-0486	LED-VISIBLE RED					
A5	DS26	6	1990-0486	LED-VISIBLE RED					
A5	DS27	6	1990-0486	LED-VISIBLE RED					
A5	DS28	6	1990-0486	LED-VISIBLE RED					
A5	DS29	6	1990-0486	LED-VISIBLE RED					
A5	DS30	6	1990-0486	LED-VISIBLE RED					
A5	DS31	6	1990-0486	LED-VISIBLE RED					
A5	DS32	6	1990-0486	LED-VISIBLE RED					
A5	DS33	6	1990-0486	LED-VISIBLE RED					
A5	DS34	6	1990-0486	LED-VISIBLE RED					
A5	DS35	6	1990-0486	LED-VISIBLE RED					
A5	DS36	6	1990-0486	LED-VISIBLE RED					
A5	DS37	6	1990-0486	LED-VISIBLE RED					
A5	DS38	6	1990-0486	LED-VISIBLE RED					
A5	DS39	6	1990-0486	LED-VISIBLE RED					
A5	DS40	6	1990-0486	LED-VISIBLE RED					
A5	DS41	2	1990-0846	DISPLAY SOLID ST					
A5	DS42	2	1990-0846	DISPLAY SOLID ST					
A5	DS43	2	1990-0846	DISPLAY SOLID ST					
A5	DS44	2	1990-0846	DISPLAY SOLID ST					
A5	J1		1251-7431	CONN POST 20M					
A5	J2		1251-7431	CONN POST 20M					
A5	J3	5	1251-7429	CONN POST 5MALE					

SECTION VII
BACKDATING

7-1 INTRODUCTION

7-2 This section contains backdating information, which adapts this manual to instruments with serial numbers lower than that shown on the title page.

7-3 CHANGE SEQUENCE

7-4 Changes are listed in the serial number order that they occurred in the manufacture of the instrument. However, in adapting this manual to an instrument with a particular serial number, apply the changes in the reverse order. That is, begin with the latest change that applies to the serial number in question. Table 7-1 lists the serial numbers to which each change applies. Where changes to components occur, alter the associated schematic and layout diagram as necessary.

Table 7-1. Manual Backdating Changes

Instrument Serial Number	Make Manual Changes
2124G00129 118, 117, 116, 109 and lower	1 to 32
2124G00140 and lower	2 to 32
2124G00160 and lower	3 to 32
2124G00194 189, 180, 176 and lower	4 to 32
2124G00285 and lower	5 to 32
2124G00365 and lower	6 to 32
2124G00405 and lower	7 to 32
2124G00505 and lower	8 to 32
2124G00565 and lower	9 to 32
2124G00635 and lower	10 to 32
2124G00695 and lower	11 to 32
2124G00755 and lower	12 to 32
2124G01085 and lower	13 to 32
2124G01185 and lower	14 to 32
2124G01235 and lower	15 to 32
2124G01285 and lower	16 to 32
2124G01335 and lower	17 to 32
2124G01485 and lower	18 to 32
2124G01735 and lower	19 to 32
2124G01905 and lower	20 to 32
2124G01940 and lower	21 to 32
2124G02085 and lower	22 to 32
2124G02145 and lower	23 to 32
2334G02345 and lower	24 to 32
2334G02495 and lower	25 to 32
2334G02570 and lower	26 to 32
2334G02620 and lower	27 to 32
2334G02645 and lower	28 to 32
2334G02670 and lower	29 to 32
2334G02695 and lower	30 to 32
2334G02845 and lower	31 to 32
2334G02895 and lower	32

CHANGE 1

For serial numbers 2124G00129, 118, 117, 116, 109 and lower.
In Table 6-3. Replaceable Parts, make the following changes to the parts lists as stated:

A1	08116-66501	VR200	DIO ZNR 5.11 V	5 %	1902-0041
		R226	R-F 1.62K	1 %	0757-0428
		R240	R-F 3.32K	1 %	0757-0433
		R243	R-F 2.05K	1 %	0698-4431
		R411	R-F 1.47K	1 %	0757-1094

CHANGE 2

For serial number 2124G00140 and lower.

In Table 6—3. Replaceable Parts, make the following changes to the parts lists as stated:

A2	08116—66502	C4	C—F	47uF	50 V	0180—2984
		C10	C—F	47uF	50 V	0180—2984
		C11	C—F	47uF	50 V	0180—2984
		C16	C—F	47uF	50 V	0180—2984
A2	08116—66512	as above.				
A3	08116—66503	C6	C—F	47uF	50 V	0180—2984
		C8	C—F	47uF	50 V	0180—2984
A1	08116—66501	C406	C—F	100 pF		0160—4389
		C407	C—F	100 pF		0160—4389
		C525	C—F	4.7 pF		0160—3873
		C527	C—F	33 pF		0160—4386
		C532	C—F	22 pF		0160—3875
		R412	R—F	511		0698—7229
		R421	R—F	1K		0698—7236
		R557	R—F	56.2		0698—7206
		W1	Jumper			8159—0005
		W6	Jumper			8159—0005
		L506	Core mag			9170—0894
		L507	Core mag			9170—0894
		R228	R—F	11	1 %	0757—0378
		R103	R—F	511	1 %	0757—0416
		R309	R—F	51.1	1 %	0757—0394

CHANGE 3

For serial number 2124G00160 and lower.

In Table 6—3. Replaceable Parts, make the following changes to the parts lists as stated:

A1	08116—66501	C501	C—F	0.1uF	20 %	0160—0576
		R157	R—F	5.36K	1 %	0698—3258
		R309	R—F	51.1K	1 %	0757—0394
MP9		PNL REAR				08116—60253

CHANGE 4

For serial number 2124G00194, 189, 180, 176 and lower.

In Table 6—3. Replaceable Parts, make the following changes to the parts lists as stated:

A1	08116—66501	R528	R—F	825	1 %	0757—0421
		R529	R—F	825	1 %	0757—0421
		R541	R—F	825	1 %	0757—0421
		R542	R—F	825	1 %	0757—0421
		R513	R—F	8.25K	1 %	0698—7258
		R422	R—F	6.19K	1 %	0757—0290
		PC BD				08116—26501
A2	08116—66502	R49	R—V	2K	10 %	2100—0567
A2	08116—66512	as above				

- 4 a) Substitute the following information for existing **Adjustment Procedures**.

Pages affected: 5–7, 5–8, 5–9, 5–10 and 5–12.

- 4 b) Page 5–7 to read:

5–11 SHAPER

EQUIPMENT

Digital Voltmeter (RMS), LF Spectrum Analyser,
Low Pass Filter as shown in figure 5–3.

PROCEDURE

1. Turn A1R413 fully CW
Turn A1R418 fully CCW

Square Amplitude

2. Set 8116A:

MODE	NORM
FRQ	1.00 kHz
DTY	50 %
AMP	9.99 V
OFS	0.00 mV
OUTPUT.....	square, normal enabled

Set DVM: AC, 10 V Range

Connect 8116A output via 50 Ohm feedthrough to DVM.
Adjust A1R410 for $5.060\text{ V} \pm 30\text{ mV RMS}$

3. Set 8116A:

AMP 16.0 V

Check amplitude $> 8.06\text{ V}$ (typ. 8.082 V).

4. Set 8116A:

AMP 1.00 V

Adjust A2 R49 for $0.506\text{ V} \pm 3\text{ mV RMS}$

Square Normal/Complement Balance

5. Set 8116A:

AMP	16.0 V
OFS	0.00 mV
OUTPUT	square, normal/complement as required, enabled

Set DVM: DC, 10 V Range.

Use DVM built in filter function, otherwise
use set up as shown in figure 5–3.

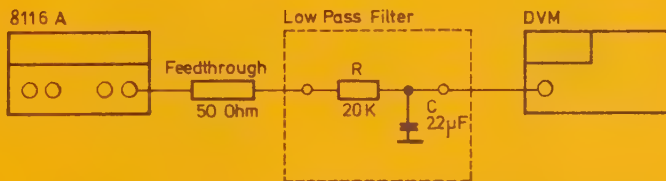


Figure 5–3. Low-pass filter test setup

Change 8116A output mode from normal to complement and back. Adjust A1R403 for minimum difference ($< 5\text{ mV}$) between normal and complement output mode.

4 c) Page 5–8 to read:

Triangle Amplitude

6. Set 8116A:

```
AMP ..... 9.99 V
OUTPUT ..... triangle, normal,
                enabled
```

Set DVM: AC, 10 V Range

Adjust A1R227 for $2.918 \text{ V} \pm 15 \text{ mV RMS}$

7. Set 8116A:

AMP 16.0 V

Check that amplitude $> 4.64 \text{ V}$

2nd Harmonic Distortion

8. Set 8116A:

```

FRQ ..... 3.00 kHz
AMP ..... 16.0 V
OUTPUT ..... sine,
                    normal/complement as
                    required enabled

```

Connect 8116A output via 50 Ohm (2 W) feedthrough to LF Spectrum Analyzer adjusting the input amplifier so that the fundamental equals 0 dB on display.

Preadjust A1R409 for minimum 3rd harmonic in normal mode. Adjust A1R417 for minimum 2nd harmonic in normal mode. Change 8116A from normal to complement mode and back. Adjust A1R407 for minimum difference between the 2nd harmonics in normal and complement mode.

Note: 2nd harmonic should be < -48 dB for both normal and complement modes.

The difference between normal and complement mode must not exceed 5 dB. To achieve this, alternating adjustment of A1R417 and A1R407 may be necessary.

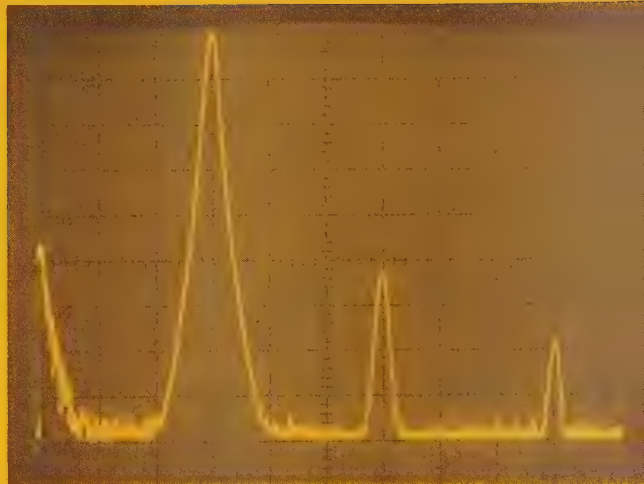


Figure 5–4. 2nd harmonic Distortion Adjust

Sine Normal/Complement balance

9. Set 8116A:

```

FRQ ..... 1.00 kHz
AMP ..... 16.00 V
OFS ..... 0.00 mV
OUTPUT ..... sine,
normal/complemen
required enabled

```

Set DVM: DC, 10 V Range

Connect 8116A output via 50 Ohm feedthrough to DVM. Use DVM built in filter function, otherwise use set-up as shown in figure 5-3.

Change 8116A output mode from normal to complement and back. Adjust A1R402 for minimum difference ($< 5 \text{ mV}$) between normal and complement output mode

If the adjustment is not possible, change * value A1R439 (see table 5—1) and repeat the procedure from step 5.

Sine Amplitude/THD

10. Set 8116A:

FRQ 1.00 kHz
AMP 9.99 V

Set DVM: AC, 10 V Range

4 d) Page 5–9 to read:

Connect 8116A via 50 Ohm feedthrough to DVM.
Adjust A1 R418 for $3.532\text{ V} \pm 10\text{ mV RMS}$.

11. Set 8116A:

AMP 1.00 V

Check that amplitude is $0.354\text{ V} \pm 5\text{ mV RMS}$.

12. Set 8116A:

FRQ 3.00 kHz
AMP 9.99 V
OUTPUT normal

Connect 8116A output via 50 Ohm feedthrough to LF
Spectrum Analyzer adjusting its input amplifier so that
the fundamental equals 0 dB on display.

Adjust A1R409 for minimum 3rd harmonic.

It should be $< -50\text{ dB}$

13. Repeat steps 10 through 12 until values are within the given limits.

14. Set 8116A:

FRQ 1.00 kHz
AMP 16.0 V

Connect 8116A output via 50 Ohm feedthrough to
DVM. Readjust A1 R418 for $5.660\text{ V} \pm 3\text{ mV RMS}$.

Triangle Normal/Complement Balance

15. Set 8116A:

FRQ 1.00 kHz
AMP 16.0 V
OFS 0.00 mV
OUTPUT triangle,
normal/complement as
required enabled

Set DVM: DC, 10 V Range

Connect 8116A output via 50 Ohm feedthrough to DVM,
use built-in filter function, otherwise use set-up as shown
in figure 5–3.

Change 8116A output mode from normal to complement
and back. Adjust A1R401 for minimum difference ($< 5\text{ mV}$)
between normal and complement output mode.

If adjustment is not possible, change * value A1R439
(see table 5–1) and repeat the procedure from step 5.

Sine Offset

16. Set 8116A:

AMP 16.0 V
OFS 0.00 mV
OUTPUT sine, normal,
enabled

Adjust A1R425 for $0.00\text{ V} \pm 10\text{ mV}$.

17. Set 8116A:

AMP 1.00 V

Adjust A1R416 for $0.00\text{ V} \pm 5\text{ mV}$.

Square low Amplitude

18. Set 8116A:

AMP 1.00 V
OFS 0.00 mV
OUTPUT square, normal,
enabled

Set DVM: AC, 10 V Range

Connect 8116A output via 50 Ohm feedthrough to DVM
Check that amplitude is $0.510\text{ V} \pm 5\text{ mV RMS}$

THD Check

19. Set 8116A:

FRQ 3.00 kHz
AMP 1.00 V

Connect 8116A output via 50 Ohm feedthrough to LF
Spectrum Analyzer and adjusting the input amplifier so
that the fundamental equals 0 dB on display.

4 e) Page 5–10 to read:

Check that 2nd harmonic < -45 dB in both normal and complement modes.

20. Set 8116A;

FRQ 50 MHz
AMP 100 mV

Connect 8116A output to HF Spectrum Analyzer (50 Ohm feedthrough or termination) and adjust its input amplifier so that fundamental equals 0 dB on display.

Check that 2nd and 3rd harmonic < -27 dB in both normal and complement.

5-12 OFFSET

EQUIPMENT

Digital Voltmeter

PROCEDURE

1. Set 8116A:

```

MODE ..... NORM
FRQ ..... 1.00 kHz
DTY ..... 50 %
AMP ..... 100 mV
OFS ..... +7.95 V
OUTPUT ..... sine, normal,
                enabled

```

Set DVM: DC, 10 V Range

Connect 8116A output via 50 Ohm feedthrough to DVM. Use DVM built in filter function, otherwise use set-up shown in figure 5-3.

Adjust A2 R43 for $+7.95 \text{ V} \pm 50 \text{ mV}$

2. Set 8116A:

OFS -7.95 V

Check that offset equals $-7.95 \text{ V} \pm 50 \text{ mV}$.

3. Set 8116A:

AMP 10.0 mV
OFS 795 mV

Check that offset equals $795 \text{ mV} \pm 4 \text{ mV}$.

4 f) Page 5–12 to read:

7. Verify that envelope distortion < 40 dB. All harmonics of the sideband should be at least 42 dB lower than the modulation sidebands.

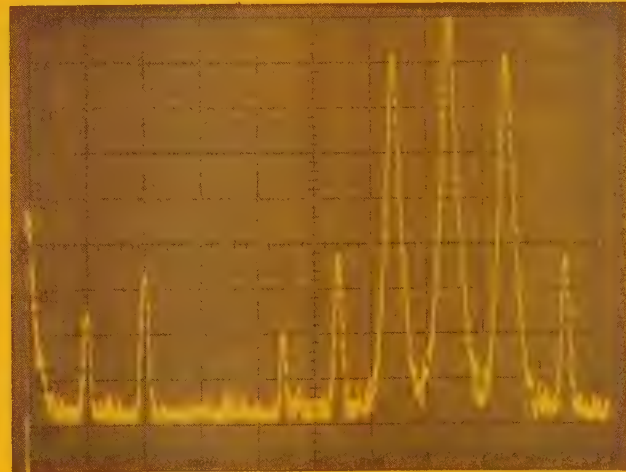


Figure 5–8. AM Envelope Distortion

8. Recheck and, if necessary, readjust steps 9, 10/11 and 15 of paragraph 5–11 SHAPER.

9. Verify again step 7.

CHANGE 5

For serial numbers 2124G00285 and lower.

In Table 6—3. Replaceable Parts, make the following changes to the parts lists as stated:

A1	08116—66511	C216	C—F	15pF	200 V	0160—4385
		R226	R—F	2.15K	1 %	0698—0084
DELETE		R70	R—F	150	1 %	0757—0284
		R71	R—F	150	1 %	0757—0284
		R72	R—F	150	1 %	0757—0284

CHANGE 6

For serial number 2124G00365 and lower.

In Table 6—3. Replaceable Parts, make the following changes to the parts lists as stated:

A3	08116—66503	DELETE C9 C—F 0.1uF 20 %				0160—0567
MP2		SHAFT PWR SW				08112—43701
A1	08116—66511	Q400	XSTR SEL PAIR			5180—2409
		R208	R—F	196	1 %	0689—7219
		R206	R—F	100	1 %	0689—7212
		MP COVER TRANS				0340—0530
		C401	C—F	4700pF	20 %	0160—0573
		R415	R—F	75	1 %	0689—7209
		R421	R—F	511	1 %	0689—7229
		R588	R—F	51.1	1 %	0689—7205
DELETE		R437	R—F	1.54K	1 %	0698—4425

CHANGE 7

For serial number 2124G00405 and lower.

In Table 6—3. Replaceable Parts, make the following changes to the parts lists as stated:

A2	08116—66502	U24	IC LIN D/A CONV			1826—0874
		C31	C—F	0.1uF	20 %	0160—0576
		R30	R—F	3.83K	1 %	0698—3153
A2	08116—66512	as above.				
MP18		FRAME REAR				5020—8814
A1	08116—66511	U300 IC RATE				

CHANGE 8

For serial number 2124G00505 and lower.

In Table 6—3. Replaceable Parts, make the following changes to the parts lists as stated:

A1	08116—66511	R157	R—F	4.75K	1 %	0757—0437
		R508	R—F	64.9K	1 %	0698—4502
A2	08116—66502	R45	R—F	4.22K	1 %	0698—3154
A2	08116—66512	as above				

CHANGE 9

For serial number 2124G00565 and lower.

In Table 6—3. Replaceable Parts, make the following changes to the parts lists as stated:

A5	08116—66505	DS41	DISPLAY NUM			1990—0531
		DS42	DISPLAY NUM			1990—0531
		DS43	DISPLAY NUM			1990—0531
		DS40	DISPLAY			1990—0649
A5	08116—66515	as above.				
A1	08116—66511	R123	R—F	442	1 %	0698—3488
DELETE		R428	R—F	14.7K	1 %	0698—7264

CHANGE 10

For serial number 2124G00635 and lower.

In Table 6-3. Replaceable Parts, make the following changes to the parts lists as stated:

A1 08116-66511	R220	R-F	2.37K	1 %	0698-3150
	R223	R-F	2.37K	1 %	0698-3150
	R242	R-F	1.1K	1 %	0757-0424
DELETE	C264	C-F	1nF 100 V		0160-3878

CHANGE 11

For serial number 2124G00695 and lower.

In Table 6-3. Replaceable Parts, make the following changes to the parts lists as stated:

A1 08116-66511	RT1	THMS	5K		0837-0035
	R429	R-F	31.6K	1 %	0698-7272
	R235	R-F	1M	10 %	0698-4073
DELETE	R236	R-F	1M	10 %	0698-4073
	R237	R-F	1M	10 %	0698-4073
	R238	R-F	1M	10 %	0698-4073
	R239	R-F	1M	10 %	0698-4073
	U401	SHAP SEL AMP			5180-2416
	MP200	HEAT SINK			1205-0235
	C502	C-F	68pF 200 V		0160-4350

Make the following changes to schematic A3 08116-66503 (Service Block 3):

- a) A3 U13 Pin 5 from EVMA to ground
- b) A3 U13 Pin 7 from +5 V to VMA
- c) A3 U12 Pin 4, 5 from EVMA to ground
- d) A3 U12 Pin 6 from +5 V to VMA

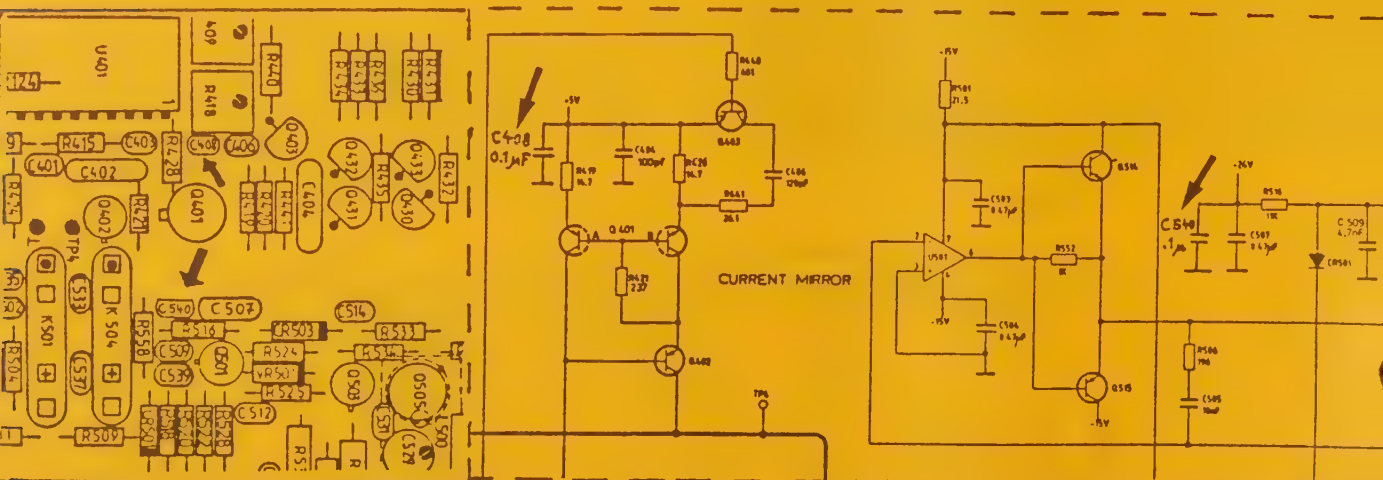
CHANGE 12

For serial number 2124G00755 and lower.

In Table 6-3. Replaceable Parts, make the following changes to the parts lists as stated:

A1 08116-66511	ADD	C408	C-F	0.1uF	20 %	0160-0576
		C540	C-F	0.1uF	20 %	0160-0576

On Service Sheet 7, change A1 Board Assy Main 08116-66511 and the Component Locator as follows:



CHANGE 13

For serial numbers 2124G01085 and lower.

In Table 6—3. Replaceable Parts, make the following changes to the parts lists as stated:

A2	08116—66502	VR2 DIO ZNR 5.6 V	1902—0952
A2	08116—66512	as above	

CHANGE 14

For serial numbers 2124G01185 and lower.

In Table 6—3. Replaceable Parts, make the following changes to the parts lists as stated:

A1	08116—66511	F1/F2 Fuse .5A	2110—0297
		U401 IC SHAPER	1826—0923
		C502 C—F 68pF 200 V	0160—4350
		C527 C—F 68pF 200 V	0160—4350
		C525 C—F 1.5pF 200 V	0160—4381
		R553 R—F 2.7	0698—8369
A2	08116—66502	R-TRMR 5k 10 %	2100—3252
A2	08116—66512	as above	
A3	08116—66503		
	DELETE	U35 IC SN74LS04	1820—1199
	ADD	U35 IC SN74LS14N	1820—1416

CHANGE 15

For serial numbers 2124G01235 and lower.

15 a) Page 3—18, paragraph 3—64 to read:

3—64 The 8116A responds to program codes in the Data message in the order in which they are received. When programming, therefore, ensure that the first parameter setting in the string is compatible with the current settings.

e.g. Current Settings: HIL = 2 V
 LOL = 0 V

Program settings: HIL = 4 V
 LOL = 2.5 V

In the example, the new HIL setting should appear first in the string. If LOL is programmed first, the new value (2.5 V) is not compatible with the current HIL setting (2 V) and therefore not accepted, a 'service request' then being sent to the controller. More information on parameter programming sequence is given under 'Error Reporting'.

15 b) Page 3–22, paragraph 3–75 to read:

3–75 Service Request. Bit 7 of the HP-IB Status Byte is usually set in conjunction with any of bits 1–4 (error indicators). However, in the case of the TIMING ERROR indication (bit 1), the 'Service Request' message can be suppressed via the command "SR 0"

e.g. (HPL) wrt 716, "SR 0"
 (BASIC) OUTPUT 716; "SR 0"

This is particularly useful for character strings where more than one timing parameter is programmed. The reason is best explained by an example:

e.g. Current Settings: FRQ 500 Hz
 WID 1 ms
 Program Settings: FRQ 1 kHz
 WID 0.5 ms

Immediately upon receiving the new frequency value (first position in string), the 8116A would set SRQ true if SRQ is active, because the new value is not compatible with the current width setting. By suppressing SRQ, both new settings for frequency and width are accepted by the 8116A without any interruption to program flow by SRQ.

Note: In the permanently stored mode/parameter settings in the 8116A's ROM's, 'SR' is set to '0'. Should these settings be called up as current settings, the service request function can be re-activated for timing errors by programming 'SR' to '1'

e.g. (HPL) wrt 716, "SR 1"
 (BASIC) OUTPUT 716; "SR 1"

15 c) Service Block 3. ROM Test. Signature Analyses to read as follows:

Pin No.	U5	U6	U7	U8	U9	U38
9	H66F	2790	I25A	9UF6	UU53	3I3C
10	24PF	7AUA	60H2	26F4	8F34	4UUP
11	HH90	047F	F63I	355U	70I2	46P0
13	50PH	CC4H	449C	C825	A6U5	8H90
14	I43P	U42C	I8UF	C8H6	8U8U	UP5F
15	96IF	5453	OP45	70U4	H204	7079
16	5U79	4U95	22FA	94P3	IAF7	3AA8
17	C92H	79FF	FF08	398I	77A3	UF58
24	P254	P254	P254	P254	P254	P254

15 d) Page 3–21, Table 3–3. Mode / Parameter Messages (cont'd)
 ADD

MESSAGE	MNEMONICS ASCII CODE
Range	
Up	RU
Down	RD

CHANGE 16

For serial numbers 2124G01285 and lower.
In Table 6–3. Replaceable Parts, make the following changes to the parts lists as stated:
A1 08116–66511 R215 R–F 3.48k 1 % 0698–3152

CHANGE 17

For serial numbers 2124G01335 and lower.

In Table 6-3. Replaceable Parts, make the following changes to the parts lists as stated:

A1	08116-66511	Q210	XSTR SI 2N3904				1854-0215
		R215	R-F	681	.125 W	1%	0757-0419
		R445	R-VAR	200 k		1%	2100-3213
		R447	R-F	23.7 k		1%	0698-3158
A2	08116-66502	R43	R-VAR	2 k	.5W	10%	2100-0567
A3	08116-66503	U5	ROM B				08116-10001
		U6	ROM A				08116-10002
		U7	ROM 9				08116-10003
		U8	ROM 8				08116-10004
		U9	ROM 7				08116-10005
		U38	ROM 6				08116-10006

Change the Signatures on the Signature Layout on Page 8-9 for the following:

08116-	10001	10002	10003	10004	10005	10006
Pin No	U5	U6	U7	U8	U9	U38
9	H66F	2790	125A	9UF6	UU53	313C
10	24PF	7AUA	60H2	26F4	8F34	4UUP
11	HH90	047F	F631	355U	7012	46P0
13	50PH	CC4H	449C	C825	A6U5	8H90
14	143P	U42C	18UF	C8H6	8U8U	UP5F
15	961F	5453	0P45	70U4	H204	7079
16	5U79	4U95	22FA	94P3	1AF7	3AA8
17	C92H	79FF	FF08	3981	77A3	UF58
24	P254	P254	P254	P254	P254	P254

ADD

A1	08116-66511	R448	R-VAR	500 k	10%	2100-0580
----	-------------	------	-------	-------	-----	-----------

On page 5-8 / 5-9, change steps 10 and 14 to read:

Sine Amplitude / THD

10. Set 8116A:

FRQ	1.00 kHz
AMP	9.99 V

Set DVM: AC, 10 V range

Connect 8116A via 50 Ohm feedthrough to DVM.
Adjust A1R448 for 3.532 V % 1mV RMS.

ADD

If A1R448 is too sensitive to achieve optimum adjustment,
turn A1R418 a little clockwise.

14. Set 8116A:

FRQ	1.00 kHz
AMP	16.0 V

Connect 8116A output via 50 Ohm feedthrough to
DVM. Readjust A1R448 for 5.660 V %2 mV RMS.

CHANGE 18

For serial numbers 2124G01485 and lower.

In Table 6-3. Replaceable Parts, make the following changes to the parts lists as stated:

A1 08116-66511 C221,222 C-F .1 μ F CER 20% 0160-0576

DELETE

A1 08116-66511 CR513,514 DIODE PWR 1kV 1A 1901-0732
R561 R-F 3.16 k .125 W 1% 0757-0279

Page 5-3, para 5-6 POWER SUPPLIES, change to read:

A1 -23 V A1R19 -23 V $\pm$ 50 mV

Page 8-18, delete diodes CR513, CR514 from Diagram 7 (near Output BNC).

Change all -24 V references in manual to -23 V.

CHANGE 19

For serial numbers 2124G01735 and lower.

In Table 6-3 Replaceable Parts, make the following changes to the parts lists as stated:

A1	08116-66511	U200	IC-TL 074 ACN	1826-0600
A2	08116-66502	U5	IC-TL 074 ACN	1826-0600
A3	08116-66503	U5	ROM B	08116-10011
		U6	ROM A	08116-10012
		U7	ROM 9	08116-10013
		U8	ROM 8	08116-10014
		U9	ROM 7	08116-10015
		U38	ROM 6	08116-10016

Change the Signatures on the Signature Layout on Page 8-9 for the following:

08116-	11011	11012	11013	11014	11015	11016
Pin No	U5	U6	U7	U8	U9	U38
9	278A	P726	873U	A4P3	HHU5	55FU
10	6A4H	PPAC	4H66	AC35	001P	384F
11	4731	U658	H178	7H9P	FA3H	H52H
13	U9H8	H7A7	30A9	9H70	936H	PH16
14	6344	CP5F	459U	61U7	64PA	6517
15	PCC0	9P52	2F1A	3061	A738	01FC
16	8P11	A30C	9C95	FH3C	PC47	P77H
17	9A08	H5UU	3719	C0C9	C5CF	HCH4
24	P254	P254	P254	P254	P254	P254

CHANGE 20

For serial numbers 2124G01905 and lower.

In Table 6-3. Replaceable Parts, make the following changes to the parts lists as stated:

A2	08116-66502	R30	R-F	3.83 k	1%	0698-3153
		R33	R-F	4.87 k	1%	0698-4444
		VR2	DIODE	ZNR 6.2 V		1902-0953

CHANGE 21

For serial numbers 2124G01940 and lower.

In Table 6-3. Replaceable Parts, make the following changes to the parts lists as stated:

A1	08116-66511	C264	C-F	1 nF			0160-3878
		R123	R-F	402	.125 W	1 %	0698-4453

DELETE

A1	08116-66511	C235	C-F	39 pF	200 V	1 %	0160-4494
		R130	R-VAR	200	10 %		2100-3212

On page 5-1, Table 5-1 make the following addition:

Voltage							Decrementing R123 value
Controlled	A1R123	383 Ohm - 536 Ohm					decreases HF Duty Cycle
Oscillator							

On page 5-6, change step 16 to read:

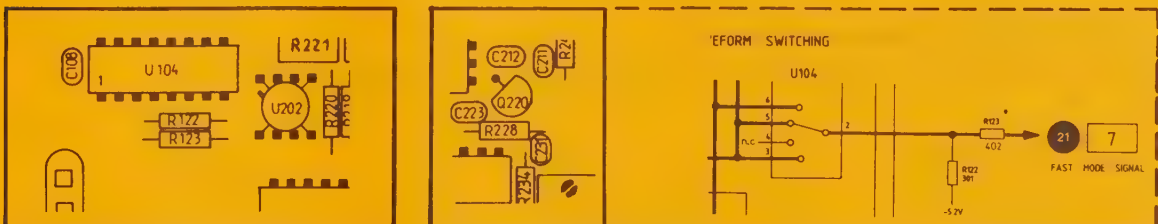
Set 8116:

FRQ	10.0 MHz
OUTPUT	square, enabled

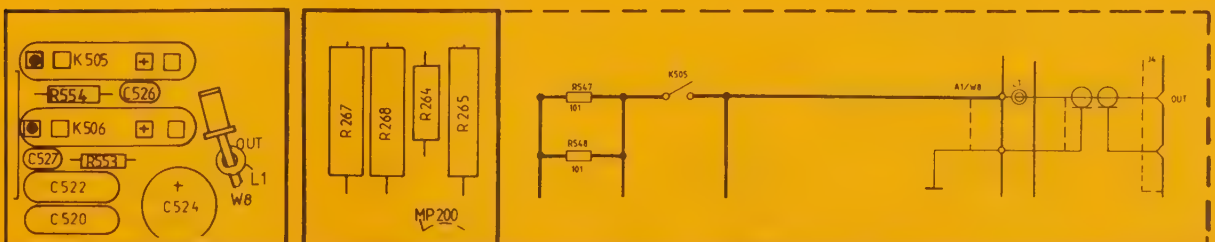
Check that Duty Cycle < 60 %. If not, change

* value A1R123 (see table 5-1).

On page 8-16, change the Component Locator and Service sheet 6 to read:



On page 8-18, change the Component Locator and Service Sheet 7 to read:



ie. remove CR513 and CR514.

ie. remove C264.

Remove diodes CR513 and CR514 from Schematic 7 (vicinity of switch K505, Output BNC).

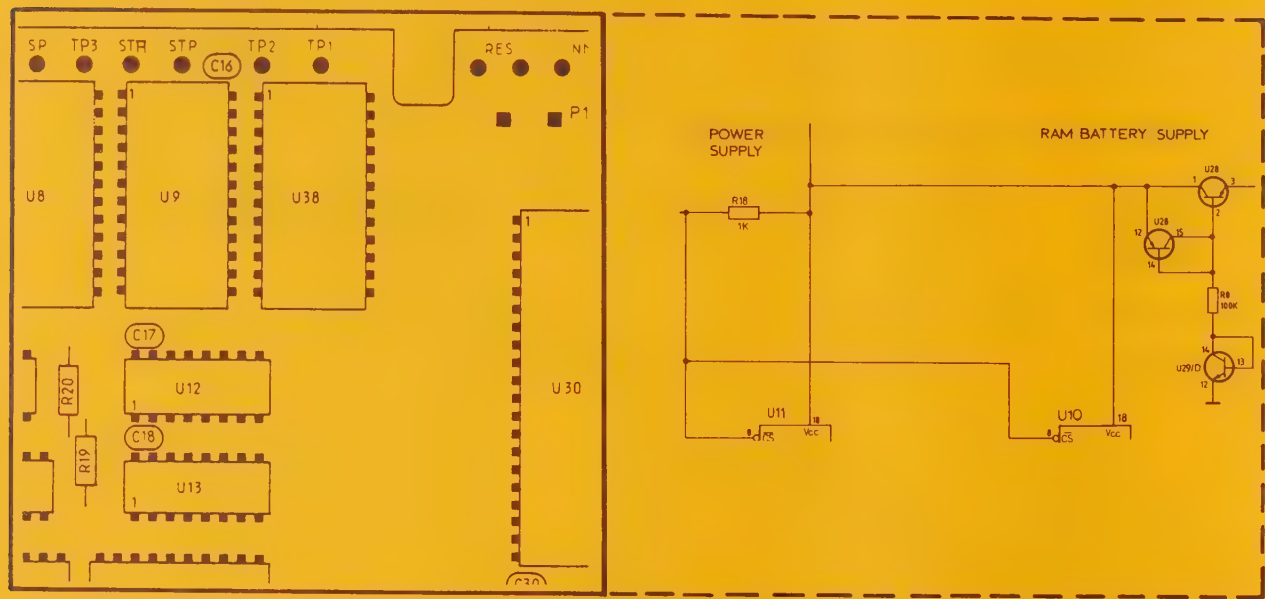
CHANGE 22

For serial numbers 2124G02085 and lower.
In Table 6-3. Replaceable Parts, make the following changes to the parts lists as stated:

DELETE

A3	08116-66503	TP5	TERM TEST POINT	0360-0535
		W2	JUMPER	8159-0005

On page 8-9, change the Component Locator and Service Sheet to read:



CHANGE 23

For serial numbers 2124G02145 and lower.
In Table 6-3. Replaceable Parts, make the following changes to the parts lists as stated:

A3	08116-66503	R15	R-NETWORK	47 k	1810-0378
----	-------------	-----	-----------	------	-----------

CHANGE 24

For serial numbers 2334G02345 and lower.
In Table 6-3. Replaceable Parts, make the following changes to the parts lists as stated:

ADD

A2	08116-66502	C31	.1 mF	CER	20%	0160-0576
----	-------------	-----	-------	-----	-----	-----------

Perform the following changes:

A1	08116-66511	R404,408	R-F	261	.125 W	1 %	0698-3132
		R405,406	R-F	1.62 k		1 %	0757-0428
		C502	C-F	120 pF		5%	0160-4512
		C530	C-F	1 pF	200V		0160-4380
		C531	C-F	2.2 pF	200 V		0160-3872
		CR505,506	DIO SI	15 V	75 ns		1901-0179
		Q510,512	XSTR	NPN	2N3866A		1854-0784
		Q511,513	XSTR	PNP	2N5160		1853-0312

DELETE

A1	08116-66511	C541	C-F	.01 μ F	100 V		0160-3879
----	-------------	------	-----	-------------	-------	--	-----------

ADD

A1	08116-66511	C525,538	C-F	1.5 pF	200 V		0160-4381
		C540	C-F	.1 μ F		20 %	0160-0576
		L508,509,510,511		CORE MAGNETIC			9170-0894
		R556	R-F	237	.05 W	1 %	0698-7221

On page 8-10, in Component Locator, replace C541 with C538.

On page 8-18, Service Sheet 7 Schematic, remove C541 located between emitters of Q508 and Q509.

CHANGE 25

For serial numbers 2334G02495 and lower.

In Table 6-3. Replaceable Parts, make the following changes to the parts lists as stated:

A1	08116-66511	R536	R-F	261	.05 W	1 %	0698-7222
----	-------------	------	-----	-----	-------	-----	-----------

CHANGE 26

For serial numbers 2334G02570 and lower.

In Table 6-3. Replaceable Parts, make the following changes to the parts lists as stated:

A1	08116-66511	C105	C-F	.01 μ F	CER	20 %	0160-0576
		C530	C-F	1 pF	200 V		0160-5380

DELETE

A1	08116-66511	C525 *	C-F	6.8 pF			0160-5738
		C538 *	C-F	1.5 pF			0160-4381
		R556 *	R-F	19.6			0698-7195

CHANGE 27

For serial numbers 2334G02620 and lower.

In Table 6-3. Replaceable Parts, make the following changes to the parts lists as stated:

ADD

A2	08116-66502	R70,71,72	R-F	150	.125	1 %	0757-0284
----	-------------	-----------	-----	-----	------	-----	-----------

Perform the following change:

A3	08116-66503	U17	IC-SN74LS138				1820-0216
----	-------------	-----	--------------	--	--	--	-----------

CHANGE 28

For serial numbers 2334G02645 and lower.

In Table 6-3. Replaceable Parts, make the following changes to the parts lists as stated:

A1 08116-66511 C112,113 C-F 6.8 μ F 35 V TA 0180-0116

CHANGE 29

For serial numbers 2334G02670 and lower.

In Table 6-3. Replaceable Parts, make the following changes to the parts lists as stated:

A1 08116-66511 R226 R-F 2.05 k 1 % 0698-4431

CHANGE 30

For serial numbers 2334G02695 and lower.

In Table 6-3. Replaceable Parts, make the following changes to the parts lists as stated:

A3 08116-66503 P1 WIRE FORM 1460-0579

CHANGE 31

For serial numbers 2334G02845 and lower.

In Table 6-3. Replaceable Parts, make the following changes to the parts lists as stated:

A1 08116-66511 C7,8,9,10 C-F 47 μ F 50 V 20 % 0180-2984

CHANGE 32

For serial numbers 2334G02895 and lower.

In Table 6-3. Replaceable Parts, make the following changes to the parts lists as stated:

A3	08116-66503	U5	ROM B	08116-10021
		U6	ROM A	08116-10022
		U7	ROM 9	08116-10023
		U8	ROM 8	08116-10024
		U9	ROM 7	08116-10025
		U38	ROM 6	08116-10026

Change the Signatures on the Signature Layout on Page 8-9 for the following:

	08116-	100021	100022	100023	100024	100025	100026
Pin No	U5	U6	U7	U8	U9	U38	
9	278A	P726	752H	1P19	HHU5	55FU	
10	6A4H	PPAC	2537	AC35	001P	384F	
11	4731	U658	6064	F764	FA3H	H52H	
13	U9H8	H7A7	431U	9H70	936H	PH16	
14	6344	CP5F	9415	61U7	64PA	6517	
15	PCC0	9P52	1F93	3061	A738	01FC	
16	8P11	A30C	0059	FH3C	PC47	P77H	
17	9A08	H5UU	8H81	C0C9	C5CF	HCH4	
24	P254	P254	P254	P254	P254	P254	

SECTION VIII SERVICE

8-1 INTRODUCTION

8-2 This section contains the information to service the HP Model 8116A. The information includes theory of operation, troubleshooting, schematics, component layouts and block diagram.

8-3 The schematics and component layouts are organized as 'Service Sheets' which are identified by a large number within a square in the lower corners. A table relating these Service Sheets to board assemblies is given in Table 8-1. Schematic diagram symbols are given in Table 8-3.

Table 8-1. Index of Assemblies

Assembly	Service Sheet
A1 Main Board	2, 6, 7
A2 (A12) Control Board	5, 8
A3 Microprocessor Board	3, 4
A4 (A14) Keyboard	4
A5 (A15) Display Board	4

NOTE: The numbers given in brackets e.g. (A12) refer to the boards as used in Option 001 (Burst) instruments where they differ from the standard type.

8-4 SAFETY CONSIDERATIONS

8-5 This section contains warnings and cautions that must be followed for your protection and to avoid damage to the equipment:

WARNING

Maintenance described herein is performed with power supplied to the instrument, and protective covers removed. Such maintenance should be performed only by service-trained personnel who are aware of the hazards involved (for example, fire and electrical shock). Where maintenance can be performed without power applied, the power should be removed. When servicing is complete, the After Service Safety Check must be performed.

8-6 AFTER SERVICE SAFETY CHECK

8-7 Execute the following checks when servicing is completed.

8-8 Disconnect power cord from line. Visually inspect interior of instrument for any sign of abnormal internally generated heat, such as discolored printed circuit boards or components, damaged insulation, or evidence of arcing. Determine cause and remedy.

8-9 Check cabinet/ground pin continuity in accordance with IEC/VDE. Flex the power cord while making the measurement to detect any intermittent discontinuity. Check internal ground connections on boards and frame. Also check resistance of any front or rear panel ground terminals marked $\perp$.

8-10 Check cabinet/line isolation in accordance with IEC/VDE. Replace any component which results in a failure or refer to production Memo or Service Note issued by product division for alternate action.

8-11 Check line fuse to verify that the proper value is installed.

8-12 Check that safety covers are installed.

8-13 Check that the coaxial and flat cables are properly connected. Check that all boards are properly fitted and the heatsink connections between the Output board A8 and front frame member are secure.

8-14 Inform Hewlett-Packard (internally, the responsible product division) of any repeated failures in the above tests or any other safety features.

8-15 SERVICE BLOCKS (THEORY/TROUBLESHOOTING)

8-16 The theory of operation and troubleshooting is divided into Service Blocks, each Service Block corresponding to a complete function within the 8116A, except Service Block 1 which deals with overall instrument troubleshooting, including a detailed block diagram of all HP 8116A functions. The purpose of the general instrument troubleshooting is to provide a fast means of isolating a fault down to a function. The Serviceman should then proceed to the Service Block providing detailed theory of operation and troubleshooting hints

for that function. A table relating function to Service Block is given in Table 8–2.

Table 8–2. Index to Service Blocks

Service Block	Functions
1	Overview and Troubleshooting Guide
2	Power Supply
3	Microprocessor
4	Device Bus Control, Keyboard and Display Board
5	Control
6	VCO and Width Generation
7	Shaper and Output Amplifier
8	(OPT. 001) Burst, Sweep and Hold

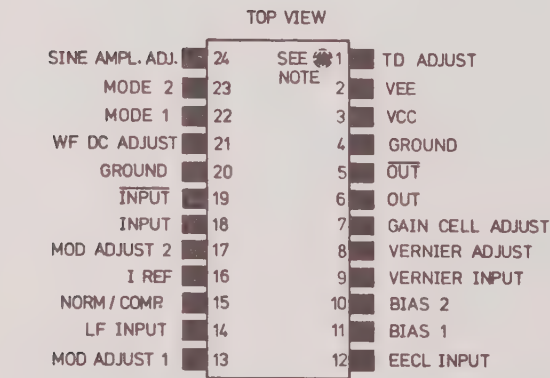


Figure 8–1 SHAPER I.C.

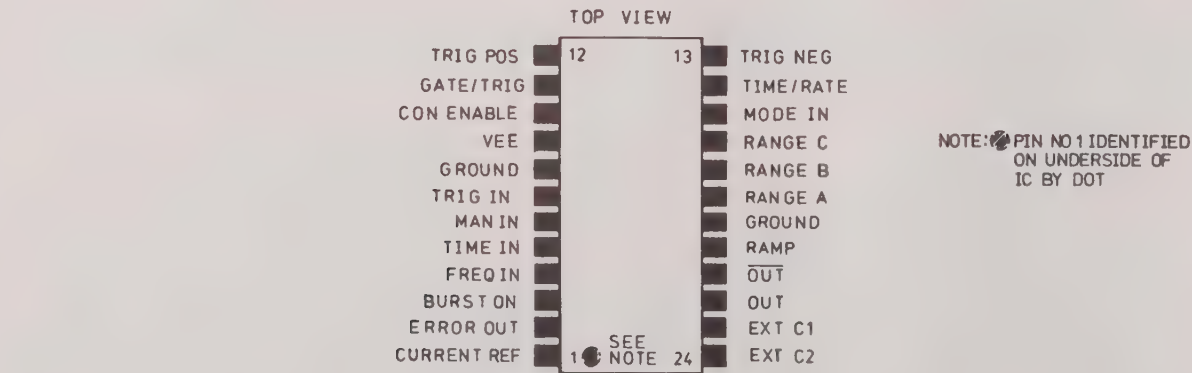


Figure 8–3 TIMING I.C.

8–17 Tables and Figures within each Service Block are given three-digit codes e.g. Figure 8–3–1. The first digit refers to the Manual Section (8), the second digit to the Service Block and the third to the Figure number, e.g. Figure 8–3–1 means Section 8, Service Block 3, Figure 1.

8–18 IC INFORMATION

8–19 Information on the three Hewlett-Packard Integrated Circuits used in the 8116A is given in Figures 8–1, 8–2 and 8–3. Detailed functional information is to be found in the Theory of Operation for each of the Service Blocks in which they appear.

Table 8-3. Schematic Diagram Notes (1 of 2)

The following symbols conform, as far as possible, with ANSI Y 32.2, IEEE No. 315 and ANSI Y32.14 (for the logic symbols). These standards should be consulted when further information is required.

Units

Resistance values are in ohms, capacitance values in microfarads and inductance values in microhenries unless otherwise noted ¹

P/O

Part of



Asterisk denotes a factory selected value. The value shown is the nominal value.



Encloses front panel nomenclature.



Encloses rear panel nomenclature.



Heavy line indicates signal path.



Heavy dashed line indicates primary feedback path.



Wire colour code. Same as resistor colour code. First number is wire body colour.



Wire or plug used as link.



Test point in a circuit. Point may/may not be identified on P.C. board.



Used with trimmer potentiometers or capacitors to indicate screwdriver adjustment.



Direct connection to earth.



Ground connection to instrument chassis or frame.



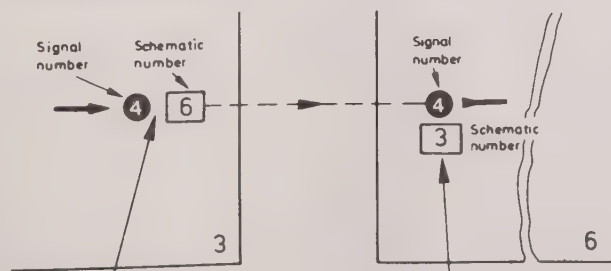
Used when a number of common-return connections are at the same potential. If there is more than one such system in the same circuit, numbers are written in the triangles so that all connections with the same potential have the same number.



Specific potential difference with respect to a potential reference level, eg.

+10 V

Schematic Referencing



These references on a signal leaving a schematic diagram indicate the signal destination. The circle contains the signal number and the square contains the number of the schematic to which that signal goes.

These references on a signal entering a schematic diagram indicate the signal origin. The circle contains the signal number and the square contains the number of the schematic to which that signal originates.

Components



Normally open toggle switch. Circles (O) are used for the contacts to indicate a locking type switch.



Spring return, 2-position transfer switch. Triangle ($\triangle$) are used for the contacts to indicate a non-locking type switch.



2-position, 2-pole slide switch.



Air cored inductor.



Air cored transformer. The dot (●) is used, when necessary, to indicate instantaneous polarity.



Iron core



Ferrite core



Ferrite bead



Varactor diode



Multi-junction diode



Diode



Zener diode



Schottky diode



Light Emitting Diode (LED)



Photodiode



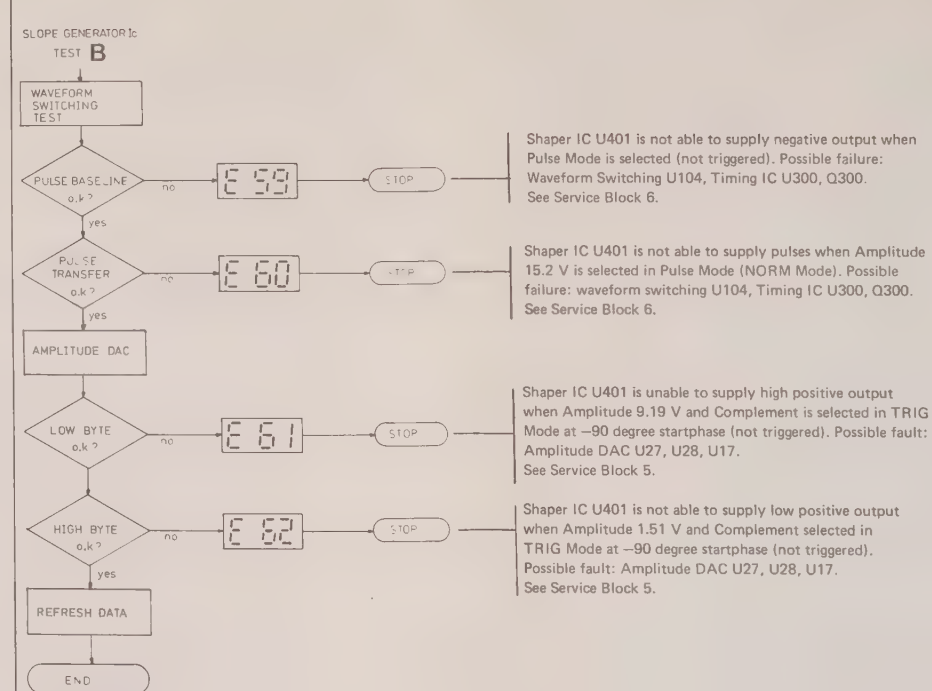
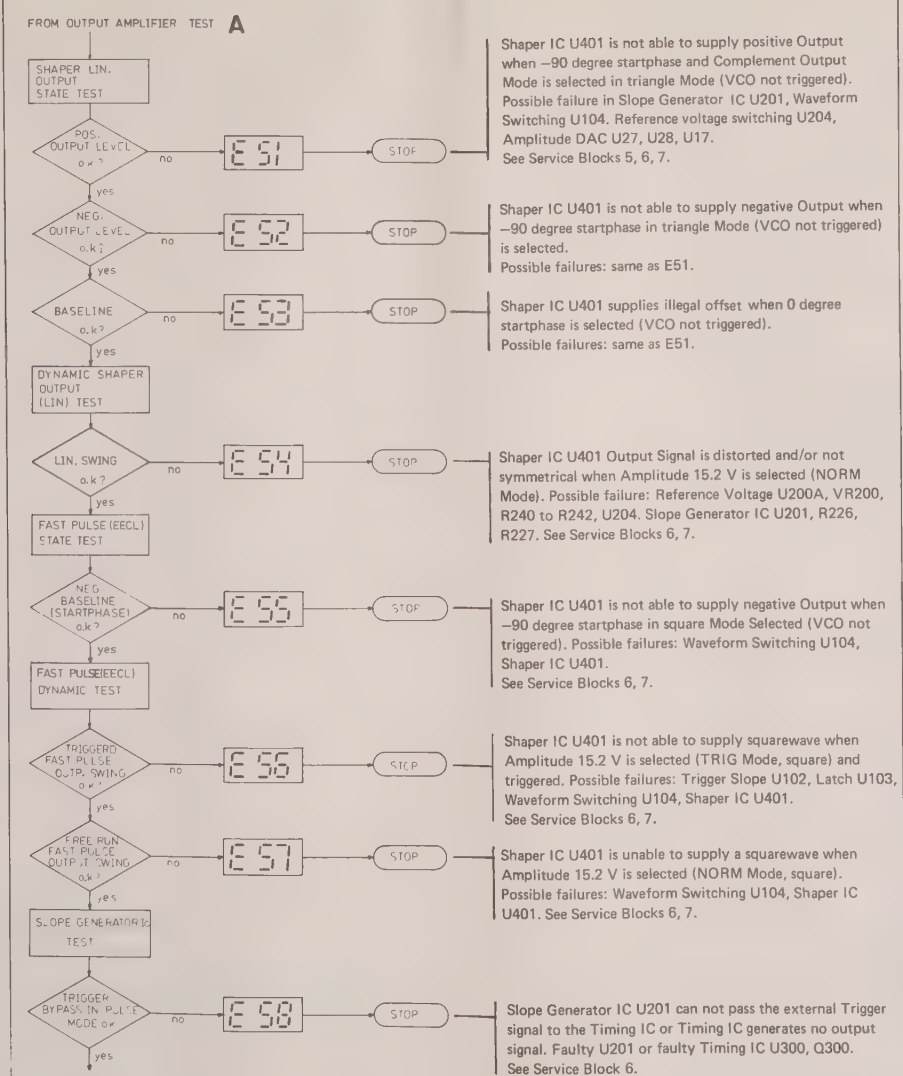
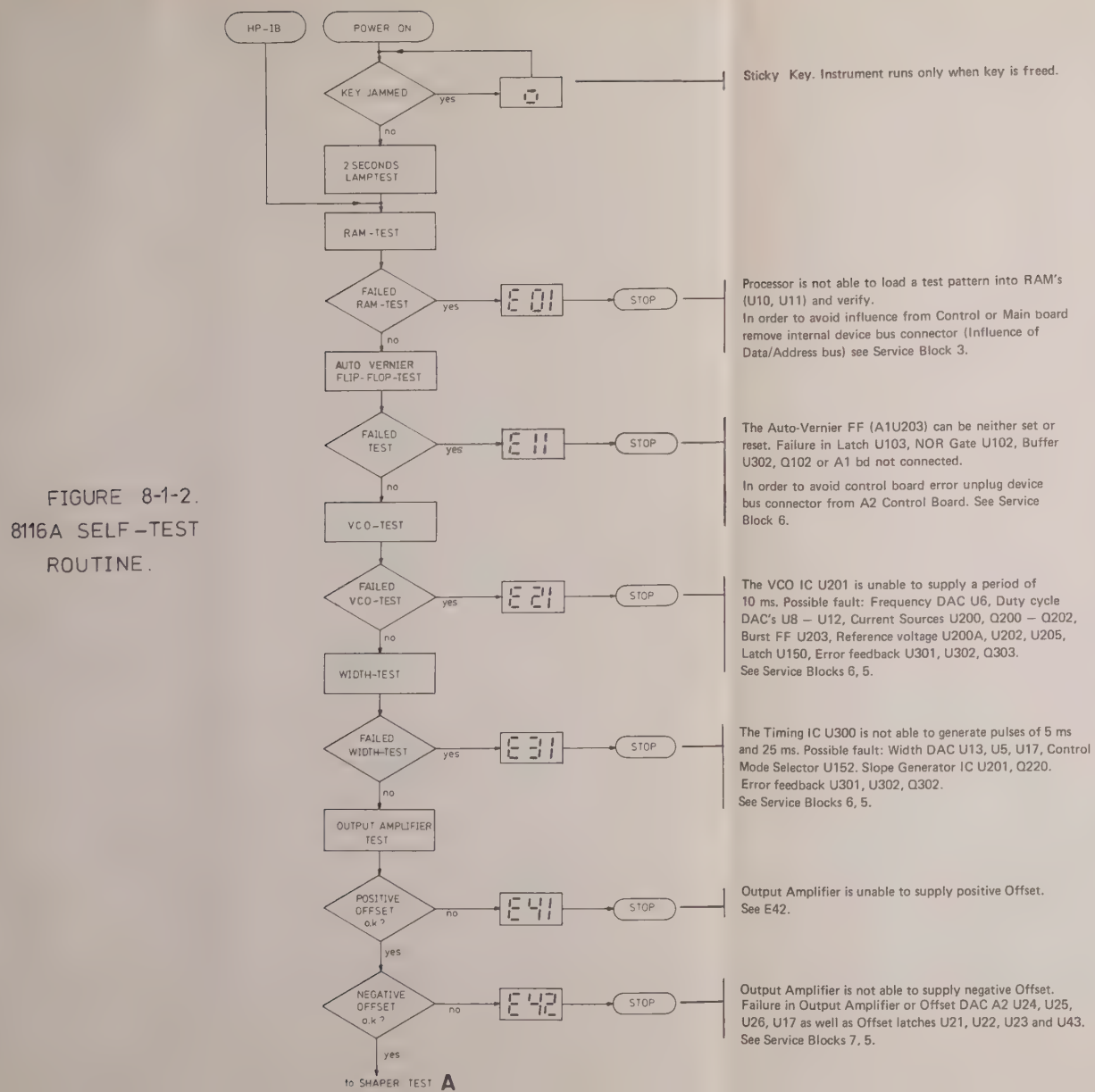
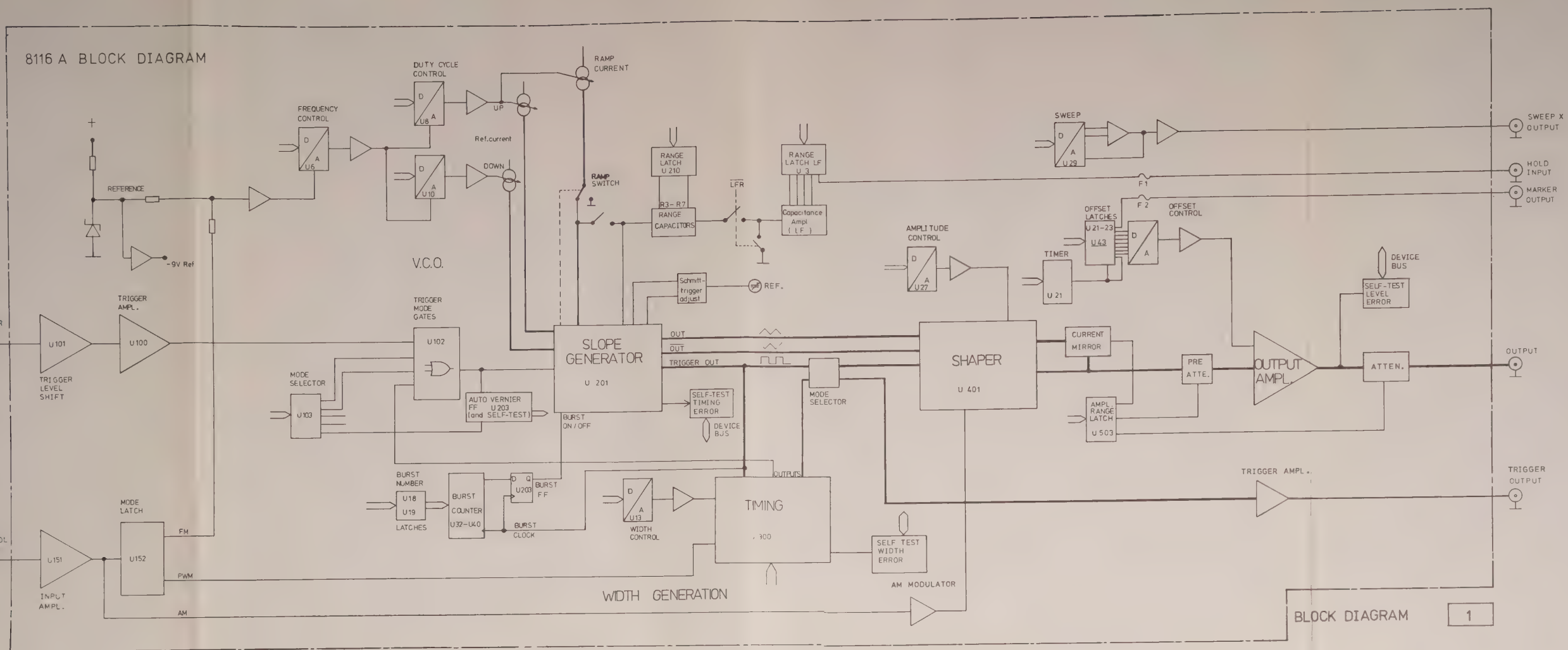
Fuse



Neon



Filament lamp



SERVICE BLOCK 1

OVERVIEW AND TROUBLESHOOTING GUIDE

General

The purpose of this Service Block is to provide a brief overview of instrument functions, thus enabling the technician to quickly isolate faults to specific areas in order to perform effective troubleshooting.

Service Blocks II to VIII deal with instrument functions in depth — each Block containing operational theory and a comprehensive troubleshooting guide.

Service Block titles and the functions covered in each are as follows:

SERVICE BLOCK II
Power Supply Rectification, Regulation, Voltage and Current sensing and Power-Down detection.

SERVICE BLOCK III
Microprocessor Microprocessor Unit, ROM's, RAM's, HP-IB interfacing, Address decoding, RESET circuits and RAM battery supply.

SERVICE BLOCK IV
Device Bus Control, Keyboard and Display Boards Control board Address decoding, Key Scanner Bus, Display Driver, Keyboard assembly and Display board assembly.

SERVICE BLOCK V
Control Byte Offset latches and Offset DAC, Timer, Address decoding, Reference circuit, DAC's and Width Vernier current source.

SERVICE BLOCK VI
VCO and Width Generation Trigger Input circuits, Control Input circuits, Slope Generator IC, Timing IC and Error Feedback and Vernier Feedback.

SERVICE BLOCK VII
Shaper and Output Amplifier Shaper IC, Amplitude Modulator, Current Mirror, Pre-Attenuator, Signal Output Amplifier, Output Attenuator and Trigger Output Amplifier.

SERVICE BLOCK VIII
(Opt. 001) Burst, Sweep and Hold Burst, Blocking flip-flop, X-output Generator, Marker Output and Hold Input.

Instrument Self-Test

At switch-on, the 8116A performs a self-test in order to ascertain that all circuits are functioning correctly. Should a fault be detected, an error message will be displayed automatically. Figure 8-1-2 is a flowchart designed to aid the technician in diagnosing the general area of any fault arising. In each case, a Service Block number is given alongside the error message. The technician should then turn to that Service Block to begin troubleshooting the fault. It may sometimes be necessary to refer to more than one Service Block in order to ascertain the location of the fault, but this will be uncommon and the operational theory will give hints on associated areas which may be at the root of the problem.

Description

Whether under HP-IB or Local (frontpanel) control, the microprocessor is responsible for all data processing in the instrument. It addresses ROM's to access stored data and RAM's for current operating data. The main Data Bus provides a highway for information between the microprocessor (with associated memory) and two secondary buses. The first of these secondary buses is the Latched Data Bus, which is the link between the microprocessor and all frontpanel functions. These are: All LED's, Range and Vernier rocker keys, Mode and Parameter keys and the Digital Display with associated Units LED's. The second of the secondary buses is the Device Bus, which handles all Control Data. This is data which is passed to the various DAC's to select current outputs required by the three specially developed HP IC's and their support circuitry.

These are:

1. VCO (Slope Generator) IC. — used as a triangle waveform generator up to 50 MHz, with signal generation free-running, gated or triggered. This IC is also used as a Burst Generator for Option 001 instruments.
2. Timing IC. — used as a triggerable pulse width generator, trigger source for Internal Burst Mode and for Pulse Width Modulation when an external signal is applied to the Control input port at the instrument frontpanel.
3. Shaper IC. — used primarily as a linear pre-amplifier and triangle to sine converter.

All three HP integrated circuits rely upon secondary circuitry for support in order to achieve their various objectives. Information in detail about these circuits is to be found in Service Blocks II to VIII.

Troubleshooting

Whenever an instrument fault is suspected, it is recommended that the 8116A be switched OFF and ON again. The self-test routine will then be executed with the result of any fault detection being represented by an error display on the instrument frontpanel.

Figure 8-1-2 is a flowchart describing the order in which tests are performed, the error codes displayed and information as to where the fault is likely to be found. It should be noted that, if a multiple fault occurs, the error code displayed will be relevant only to the first fault detected. On successful diagnosis and remedy of the displayed error cause, the instrument will display, after switch-on, the next error code if a fault still exists.

Preparing the instrument for Service.

1. Remove all four feet at the rear of the instrument by unscrewing the fastening screws.
2. Remove the single screw securing the cover to the rear panel.

3. Slide the cover backwards to reveal the inside of the instrument.

4. To set the boards in the instrument to their Service positions, lift each carefully (individually) and stand in the vertical position by placing the cut-outs on the edge of the board over the locating lugs on the inside of the side panel.

Board assy A2 (08116-66502 or 66512) control is positioned on the left when viewing the instrument from the front, with components facing outwards. Board assy A3 (08116-66503) should be located on the right.

Figure 8-1-3 shows the instrument in its Service position.

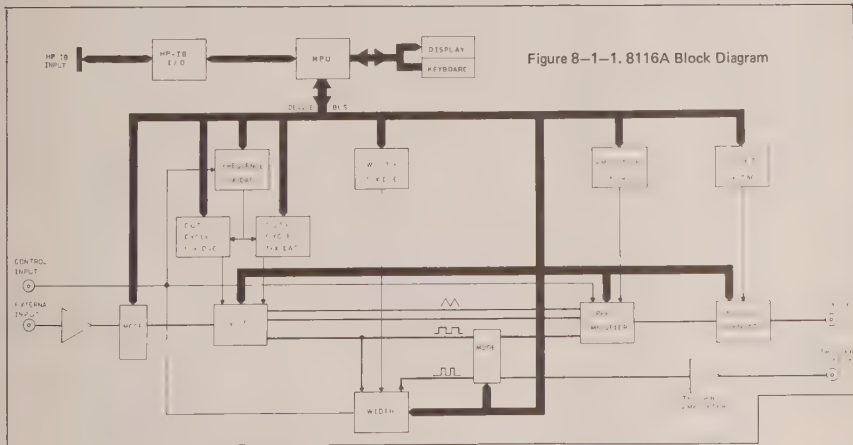
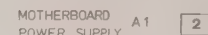
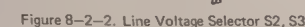
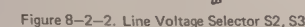


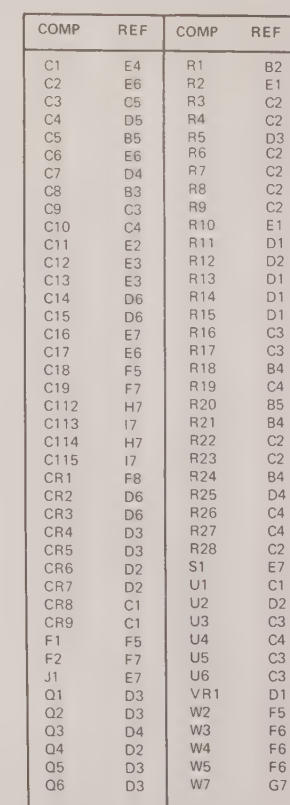
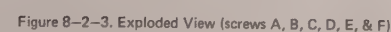
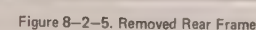
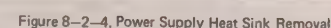
Figure 8-1-1. 8116A Block Diagram



NOTE: If an error code is shown in the display it is necessary to press a key e.g. LCL, to set the u-Processor to normal routine, then troubleshoot the instrument.

Fan and Transformer Removal Procedure

- After disconnecting the respective wires, unscrew the fan and remove the transformer.



SERVICE BLOCK 2

POWER SUPPLY THEORY OF OPERATION

Introduction

The 8116A power supply unit occupies part of BD AY A1, and four sections, as follows:

- 1. Line voltage selector and transformer.
- 2. Bridge Rectifier circuits and regulators.
- 3. Voltage and current sensing circuits.
- 4. Power Down Detection.

A reference voltage of 6.2 V is derived from the +15 V regulated supply, using zener diode VR1 and R12. Comparators U1A and U1C perform current and voltage sensing tasks respectively. U1C compares the output voltage with the reference voltage and drives the regulator transistor Q1 via driver transistor Q2 to zero difference.

- 1. Line voltage selection is accomplished by moving the two slider switches on the side panel of the instrument to the desired positions. The transformer provides six a.c. outputs and an earth line to the Bridge Rectifiers.

- 2. Bridge Rectifiers and Regulators.
There are three rectifiers, all modular and therefore replaceable. CR1 provides ± 5 V DC, CR2 provides +24 V DC and -23 V, and CR3 provides ± 15 V DC. All raw supplies are smoothed by means of capacitors across the rectifier outputs (see Figure 8-2-1). The following supplies are fed to modular regulators, the output of each being adjustable by means of a potentiometer: +24 V (U3 and R18), -23 V (U4 and R19) +15 V (U5 and R24) and -15 V (U6 and R25).

When the current taken by the load through R2 becomes excessive, resulting in a distinct voltage drop across the resistor, the output of U1A (normally high) switches toward the negative supply of the device. This action forward-biases diode CR8. Q2 and, therefore, Q1 are effectively switched-off, and the 5.1 V supply is withdrawn.

The above principle of operation applies to the +5 V current sensor (U2D); and voltage regulator (U2C). It will be noted that op-amp U2A is used as an inverter with a gain of 1.04. However, the potential seen by the inverting input of comparator U2D will still be positive by virtue of the divider R28 (1K) and R6 (61.9K).

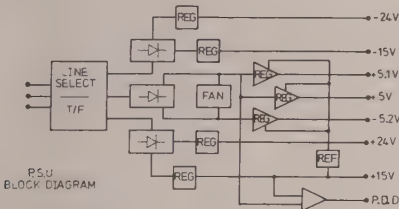


Figure 8-2-1. PSU block diagram

- 3. Voltage and current sensing circuits.
The DC output of CR1, when smoothed, drives the instrument fan and provides the basis of the sensing circuits, the operation of which are described in the following text.

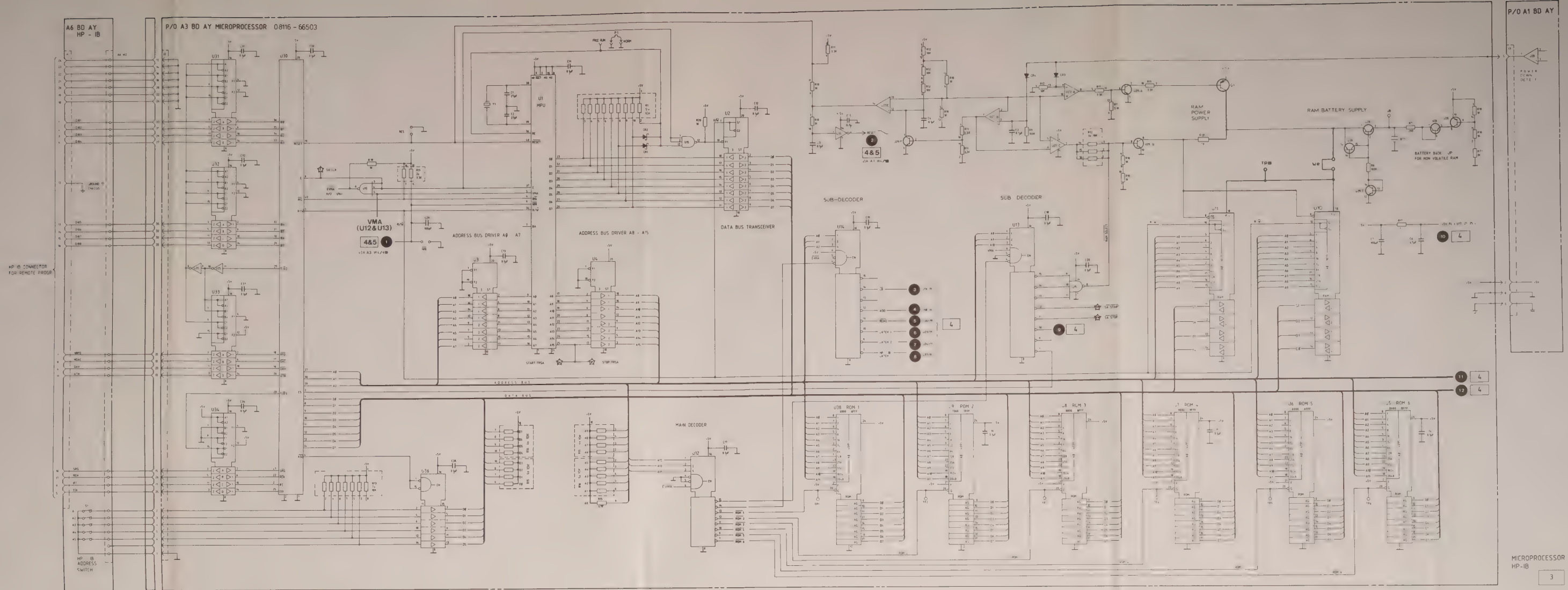
The -5.25 V current sensor (U1B) and voltage regulator (U1D) both adopt the same principle of operation as above, the exceptions being that the comparator output is normally of a negative status — going positive when a fault condition arises, and the reference voltage has to be negative (achieved by the inverter U2A).

4. Power Down Detection.

Power Down Detection is accomplished via comparator U2B, the output of which is normally negative due to the inverting input having a higher potential than the non-inverting input. When the instrument is turned off, the +5.1 V supply breaks down faster than the reference voltage due to the high load (uP., etc.). This is detected by U2B, the output of which will switch towards the value of its positive supply, with the following consequences to the microprocessor board: To examine what happens when the Power Down Detect signal is sent, (instrument turn off), it is important to know the status of relevant circuits under normal operating conditions. These are: uP bd assy A3, U27A output high, U29A on, Q1 on, thus supplying +5 Vcc to U10 and U11. U27B output low, U27C output high, enabling U29B feeding the RAM SELECT signal to the $\overline{CS}$ inputs of U10 and U11. The RAM Battery Supply is matched by Vcc and, therefore, the battery charges from the +5V supply. U27B low output also switches U29C OFF, U27D output being high, thus ensuring that the $\overline{RESET}$ signal to the microprocessor U1) and HP-IB interface (U30) is in the false state (high).

Upon receipt of the Power Down Detect signal (positive voltage), the circuits on the microprocessor board respond as follows: U27A output goes low, switching U29A and hence Q1 off. U27B output goes high ensuring that U27C output goes low, which turns U29B off. The +5 V (Vcc) supply has now been removed from U10 and U11, and the CS signal is in the false state (high). U27B output, now high, switches U29C on, causing U27D output to go low. Thus, the $\overline{RESET}$ signal to U1 and U30 assumes its true state (low), and both the microprocessor and HP-IB interface are inactive. Upon withdrawal of the +5 V (Vcc) supply by the action of Q1 being turned off, the battery to RAM current path is established, preventing U10 and U11 from actually being switched off. Thus the last set of data stored in the RAMs is retained.

At turn-on U27D output remains low until C4 is charged up via U12. As a result, the $\overline{RESET}$ signal (U27D output) goes high and initiates the restart sequence of the microprocessor.



SERVICE BLOCK 3 TROUBLESHOOTING GUIDE

NOTE: If an error code is shown in the display it is necessary to press a key, eg LCL, to set the u-Processor to normal routine, then troubleshoot the instrument.

Free Run Signature Analysis

For Signature Analysis purposes the u-Processor is set to a free run routine which makes it increment through all addresses continuously. This is achieved by giving some hardware programmed command to the u-Processor which increments the address register by one continuously via CR1 and CR2, when jumper P1 is set to "Free Run" position.

The NMI input has to be held at high potential, so disconnect wire A2W2.

Before the u-Processor accepts the hardware programmed command it has to be reset by shorting RES to ground for a short time.

Address Bus Drivers, Main Decoder and Subdecoders

The Address Bus Drivers/Decoders can be checked by signature analysis. Set u-Processor to "Free Run" by setting jumper P1 to position "P1" on board A3, disconnecting wire A2W2 and resetting the u-Processor. Set and connect the Signature Analyzer as given in table 8-3-2.

Signature Analyzer	A3 u-Processor Board Assy
Start	TP "SA"
Stop	TP "SP"
Clock	TP "E"
⊥	⊥

Table 8-3-2. Signature Analyzer setting and connection to A3 u-Processor Board Assy for Address-Decoder/Decoder Test

NOTE: Verify that reading at +5 V is 0003. If not, the u-Processor is not free-running.

Check the signatures for U3, U4, U10, U11, U12, U13, U14 and U36 against the signatures given in the signature analysis layout. Set u-Processor to "free run" as described above.

ROM TESTING

Signature Analyzer	A3 u-Processor Board Assy
Start	TP1 for U38, TP2 for U9, TP3 for U8 etc.
Stop	TP "E"
Clock	⊥
⊥	⊥

Table 8-3-3. Signature Analyzer setting and connection to A3 u-Processor Board Assy for ROM-Test

NOTE: Verify that reading at +5 V is P254. If not, the u-Processor is not free running.

EXCHANGING ROM's

When exchanging ROM's, the data saved in the RAM during periods of power-off has to be made compatible with the new ROM data. This can be achieved by setting the 8116A to an error condition, e.g. "E.WID" and "SINE", then turning the instrument OFF and ON again.

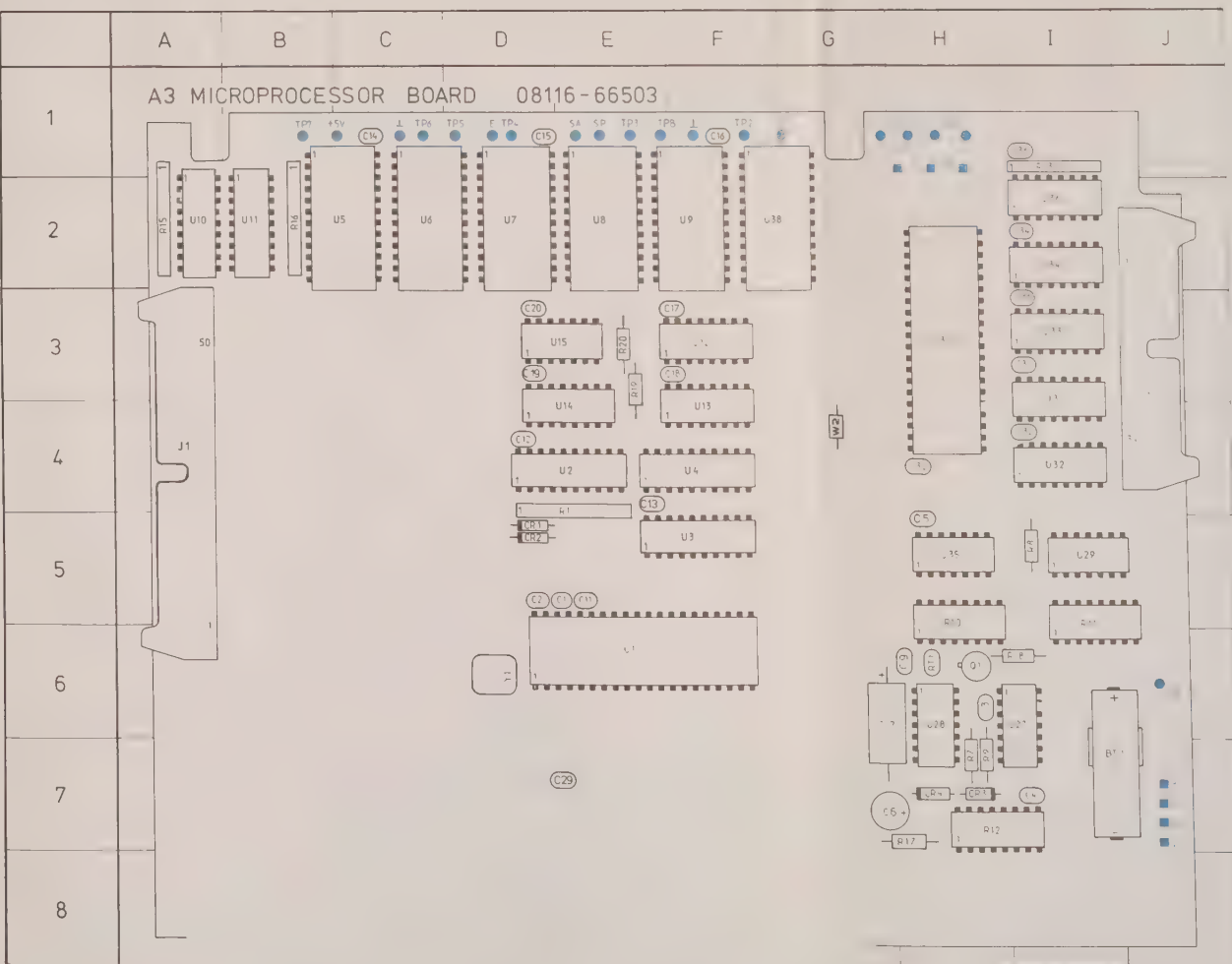
Should a processor "hang-up" occur, rendering the instrument inoperable, switch the instrument OFF and disconnect the RAM back-up battery for 30 seconds. This will have the effect of destroying stored data. Reconnect the battery, and switch the instrument ON. The standard Parameter Set will now be loaded into the RAM.

Pin No.	U3	U4	U12	U13	U14
1					
2	6F9A	0002			
3					
4	U759	9U1P1			
5					
6	0356	4868	4 P4	748C	PHOC
7					
8					
9	U05P	4FCA	31AC	8069	CGP1
10			36F8	U638	H03A
11			4885	9CPIH	6P25
12	P/O3	6U28	20U0	359H	CR88
13			8H7	H883	P25P
14	8484	37C5	1066	0A9U	88C7
15			2340	5HP5	26H1
16	FFFF	6321			
17					
18	UUUU	7791			

Pin No.	U10	U11	U36
1			
8	8UP9	8UP9	6W7C

ROMS

Pin No.	U5	U6	U7	U8	U9	U38
9	278A	P726	752H	IP19	HHU5	55FU
10	6A4H	PPAC	2537	AC35	001P	384F
11	4731	U658	6064	F7G4	FA3H	H52H
12	U9H8	H7A7	431U	9H70	996H	PH16
13	6344	CP5F	9415	61U7	64PA	65U7
14	PGC0	9PR2	H93	3061	A738	01FL
15	8PI	A30C	0059	FH3C	PC47	P77H
16	9A08	H5U0	8HB	COC9	C56F	HCW4
24	P254	P254	P254	P254	P254	P254



COMP	REF	COMP	REF
C1	E5	R12	H7
C2	D5	R13	I2
C3	H6	R15	A2
C4	I7	R16	B2
C5	H5	R17	H7
C6	G7	R18	I6
C7	G6	R19	E3
C8	H6	R20	E3
C11	E5	R11	H6
C12	D4	U1	E6
C13	F4	U2	E4
C14	C1	U3	F5
C15	D1	U4	F4
C16	F1	U5	C2
C17	F3	U6	C2
C18	F3	U7	D2
C19	D3	U8	E2
C20	D3	U9	F2
C29	D7	U10	A2
C30	H4	U11	B2
C31	I3	U12	F3
C32	I4	U13	F4
C33	I3	U14	E4
C34	I2	U15	E3
C36	I1	U27	H6
CR1	D5	U28	H6
CR2	D5	U29	I5
CR3	H7	U30	H3
CR4	H7	U31	I4
P1	H1	U32	I4
Q1	H6	U33	I3
R1	E5	U34	I2
R7	H7	U35	H5
R8	I5	U36	I2
R9	H7	U38	F2
R10	H6	V1	D6
R11	I6	BT1	I7
		W2	G4

SERVICE BLOCK 3

MICROPROCESSOR BOARD THEORY OF OPERATION

Controller

The controller is the data processing and information center of the 8116A Programmable Pulse/Function Generator. The control information required by the instrument is generated here, depending on inputs from one of two sources.

- Frontpanel inputs when under manual control.
- HP-IB inputs when under remote control.

During operation, inputs from one of these sources program the desired output parameters.

These parameters are:

Frequency, Duty Cycle, Width, Amplitude, Offset, High Level, Low Level, Operating and control modes, Output and its associated functions such as Auto Vernier, Complement and Limit.

Additional parameters of the 8116A option 001 version are Start, Stop, Marker-Frequency, Sweep Time, Repetition Rate and Burst Number. When the instrument is in the remote control mode, all frontpanel keys with the exception of LCL are disabled (unless the Local Lockout command has been sent along the HP-IB in which case, LCL is disabled too), and parameters can only be entered via the HP-IB.

The controller is comprised of the following major segments:

- Microprocessor Unit (MPU)
- Read Only Memory (ROM)
- Random Access Memory (RAM)
- HP-IB Interface (GPIA)
- Address Decoder
- RESET Circuit
- RAM Battery Supply

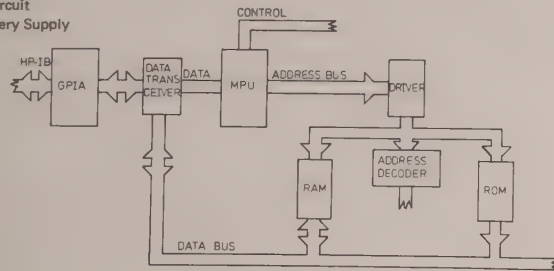


Figure 8-3-2. Bus configuration

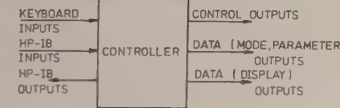


Figure 8-3-1. CPU input and output signals

The purpose of the MPU is to execute the functions (routines) programmed into the ROM array. Figure 8-3-1 indicates the input and output signal of the MPU. The MPU has an internal clock oscillator whose timing is controlled by an external quartz crystal. It contains two buses, an eight bit bidirectional data bus and a sixteen bit address bus. The function of the address bus is to address a particular memory location, either ROM, RAM or the GPIA (General Purpose Interface Adapter). The address decoder, also connected to the address bus, enables one of these elements. In the case of a RAM or the GPIA, the MPU also controls read and write modes. Data can then be transmitted over the bidirectional data bus connected to the MPU. Figure 8-3-2 illustrates the microprocessor bus configurations.

2. Read Only Memory

The Read Only Memory is a device in which operational data is stored at manufacture. It can be read from but not written into. Data in a particular ROM location may be accessed by addressing that memory location and enabling the ROM. Addressing and reading data takes place on the address bus and data bus respectively. The 8116A uses ROM's requiring a twelve bit address, giving each device 4096 individual memory locations.

When enabled, the ROM outputs data from the addressed location to the data bus, so for practical purposes, the ROM may be considered as a decoder which transforms input addresses into specific output instructions. To perform a routine (set of specified instructions), the MPU addresses the first memory location of routine data and responds to the instruction it reads. When the instruction has been executed, the MPU addresses the next location, reads the instruction and responds. This cycle is continued until the complete routine has been executed. Some instructions may branch the controller to a sub-routine, while others are directed to the instrument based upon information stored in the ROM's.

3. Random Access Memory (RAM)

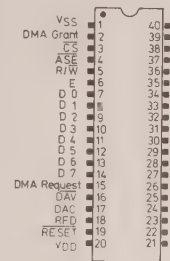
The Random Access Memory is the "scratchpad" element of the controller. Data in a memory location is destroyed each time new data is written in. Because Data is written in, read out at a later time and finally destroyed by new data, the contents of the RAM are never considered to be permanent, thus the term "scratchpad". Data stored in a RAM is also normally destroyed when power to the device is withdrawn. However, the 8116A has a 1K byte RAM which stores all current operating data when the instrument is switched off, due to a battery back-up.

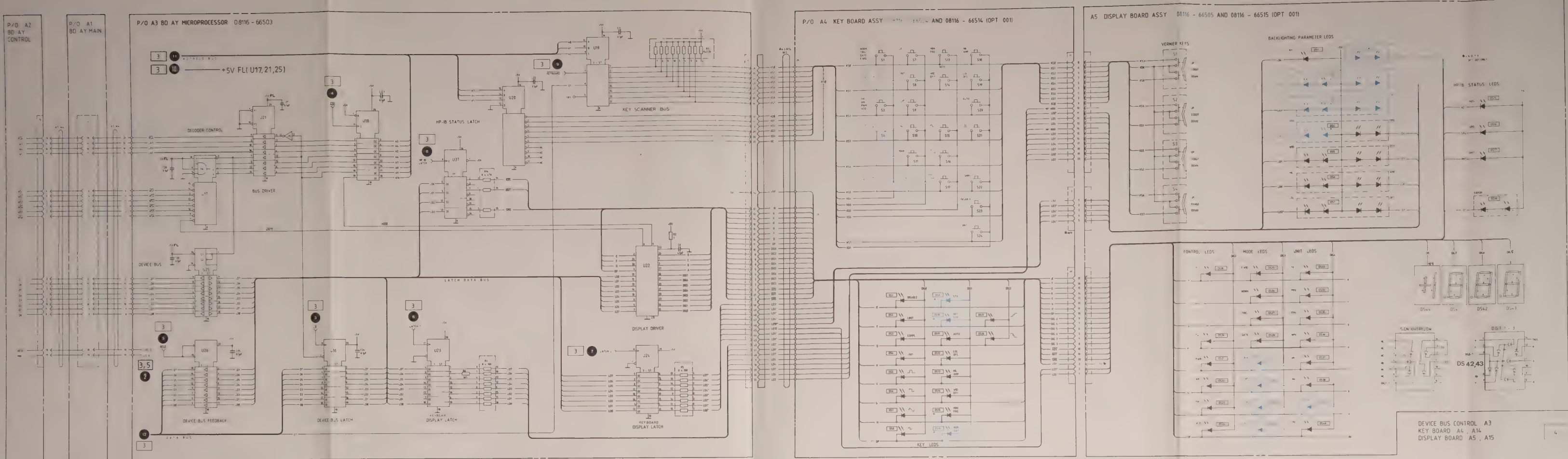
RAM's contain two buses — an address bus (10 bits in this case) for the addressing of a particular memory location, and a bi-directional data bus for transmitting data in the read mode and receiving data in the write mode. Both RAM buses are connected to the respective MPU buses. The address decoder is also connected to lines of the address bus and controls the enabling/disabling of each RAM. Read and write functions are controlled by a single line from the MPU. Thus the MPU can enable and address a RAM for a read or write function.

4. HP-IB General Purpose Interface Adapter (GPIA)

The GPIA is part of the HP-IB section of the instrument and is merely an interface device between the MPU (and associated circuitry) and any other equipment operating on the HP-IB. Figure 8-3-3 shows the GPIA — MC 68488 — pinout configuration, while Table 8-3-1 describes the pinout functions. The pinouts can be divided into three groups:

- MPU Interface
- Interface between 8116A and other equipment on the HP-IB via bus drivers
- Control Signal group.





SERVICE BLOCK 4 TROUBLESHOOTING GUIDE

NOTE: If an error code is shown in the display it is necessary to press a key, e.g. LCL, to set the u-Processor to normal routine, then troubleshoot the instrument.

Keyboard

The keyboard can be checked with help of signature analysis at A3 TP7 when the u-Processor is in free run mode. To set the u-Processor to free run mode set jumper P1 into position P1 on board A3. Disconnect jumper W2 on Control Board A2. Connect RES to gnd. for a short time to reset the u-Processor.

Signature Analyzer	A3 u-Processor Board Assy
Start	TP "SA"
Stop	TP "SP"
Clock	TP "E"

Table 8-4-2. Signature Analyzer setting and connection to A3 u-Processor Board Assy

NOTE: Verify that reading at +5 V is 0003. If not, the u-Processor is not free running. Press one key after another and check the signature for each key at TP7 against table 8-4-3.

Bus Driver/Decoder Control Signature Analysis

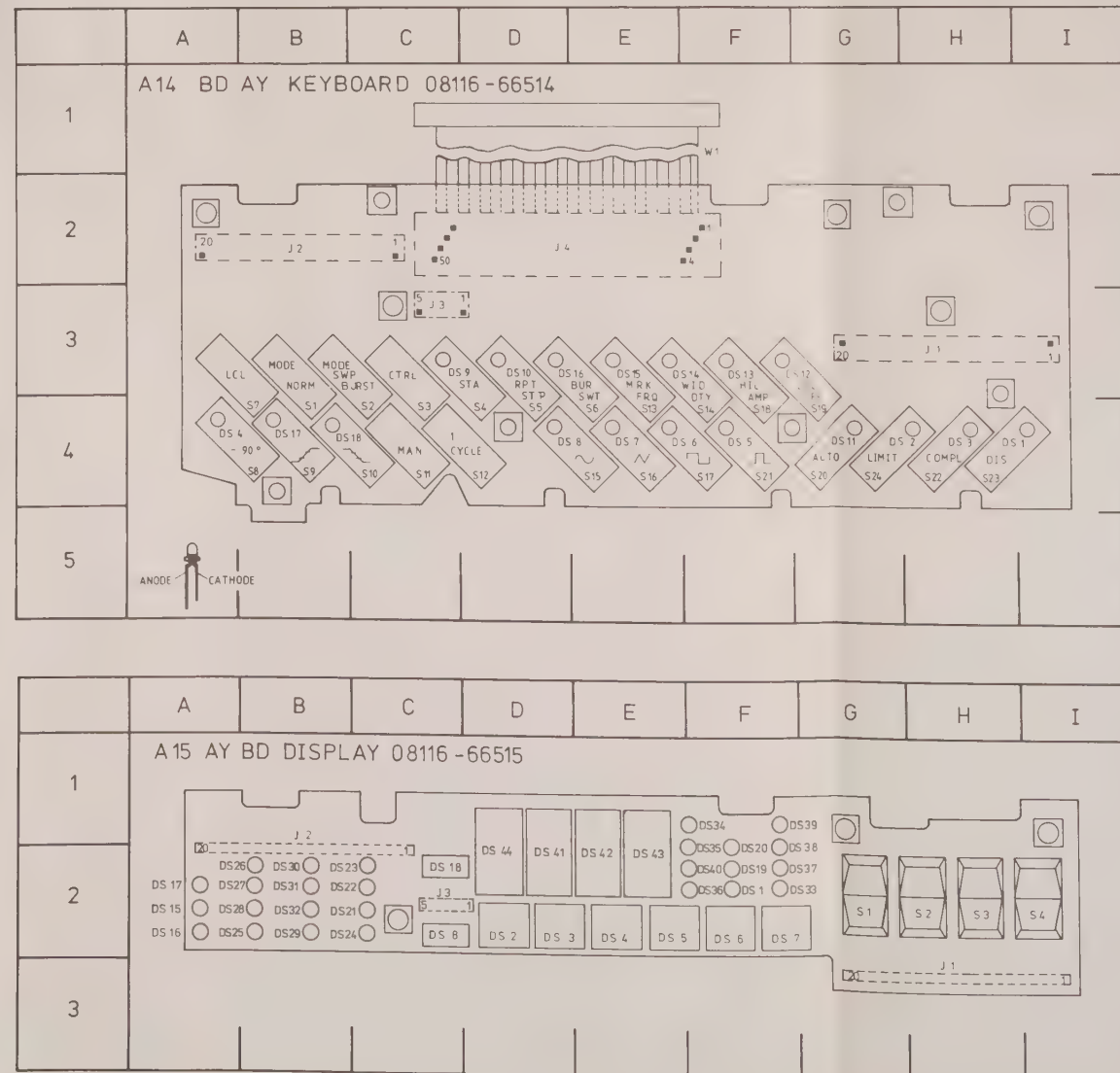
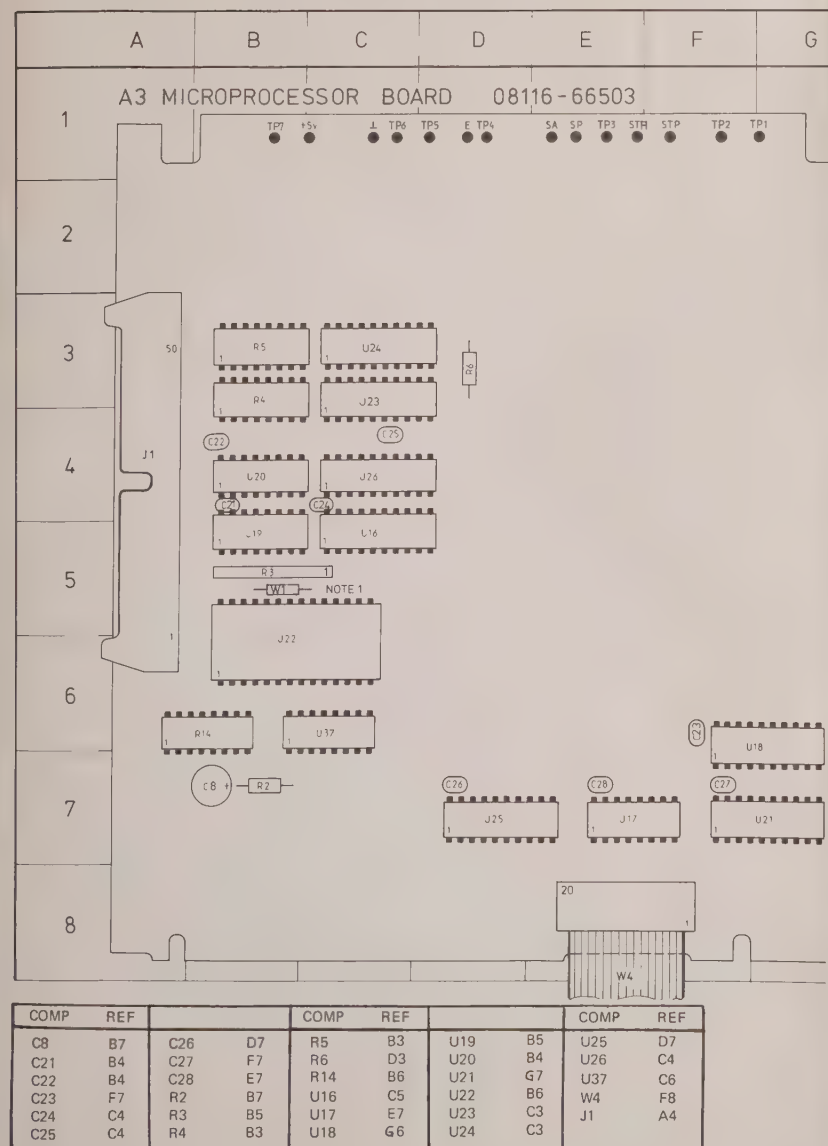
Set u-Processor to free run mode as described above. Set and connect Signature Analyzer as given in table 8-4-2.

Pin No.	U17	U18	U21
2		P50H	P50H
3		C-HF6	3B17E
5		8155	3B17E
6		3B17E	3B17E
7	5U3F	3B17E	3B17E
9	IFH6	3B17E	3B17E
10	8U95	3B17E	3B17E
11	55F4	0B08	3B17E
12	79HU	0B08	3B17E
13	PU99	0B08	3B17E
14	IP50	0B08	3B17E
15		0B08	3B17E
16		0B08	3B17E
18		0B08	3B17E
19		0B08	3B17E

Key	TP7 Reading	
	Option	Standard
no key pressed		
LCL		
MODE 1 (Norm, Trig etc)		
MODE 2 (Sweep, Burst)		
CTRL (AM, FM, etc)		
STA		
STP, RPT		
SWT, BUR		
FRQ, MRK		
DTY, WID		
HIL, AMP		
LOL, OFS		
-90°		
Slope		
Slope		
MAN		
1 Cycle		
Auto Vernier		
Limit		
Complement		
Disable		
Vernier MSD UP		
Vernier MSD DOWN		
Vernier SSD UP		
Vernier SSD DOWN		
Vernier LSD UP		
Vernier LSD DOWN		
Range UP		
Range DOWN		

Table 8-4-3. Keyboard Signatures

HP-IB Latch	READ	LB
Latch 1		
Latch 2		



COMP	REF	COMP	REF
DS1	I4	S4	C3
DS2	H4	S5	D3
DS3	H4	S6	D3
DS4	A4	S7	A3
DS5	F4	S8	A4
DS6	E4	S9	B4
DS7	E4	S10	B4
DS8	D4	S11	C4
DS9	C3	S12	C4
DS10	D3	S13	E3
DS11	G4	S14	E3
DS12	G3	S15	D4
DS13	F3	S16	E4
DS14	E3	S17	E4
DS15	E3	S18	F3
DS16	D3	S19	F3
DS17	B4	S20	G4
DS18	B4	S21	F4
J1	H3	S22	H4
J2	B2	S23	I4
S1	B3	S24	G4
S2	B3	W1	D/E1
S3	C3		

COMP	REF	COMP	REF	COMP	REF
DS1	F2	DS22	C2	DS37	F2
DS2	D2	DS23	C2	DS38	F2
DS3	D2	DS24	C2	DS39	F1
DS4	E2	DS25	A2	DS40	F2
DS5	E2	DS26	A2	DS41	D2
DS6	F2	DS27	A2	DS42	E2
DS7	F2	DS28	A2	DS43	E2
DS8	C2	DS29	B2	DS44	D2
DS15	A2	DS30	B2	J1	H3
DS16	A2	DS31	B2	J2	H3
DS17	A2	DS32	B2	J3	C2
DS18	C2	DS33	F2	S1	G2
DS19	F2	DS34	F1	S2	H2
DS20	F2	DS35	F2	S3	H2
DS21	C2	DS36	F2	S4	I2

SERVICE BLOCK 4

DEVICE BUS CONTROL, KEYBOARD, DISPLAY BOARD THEORY OF OPERATION

General Description

The Device Bus Control section is part of MPU bd Assy, and provides necessary interfacing between 2 general instrument areas:

MPU/ROM's and Keyboard/Frontpanel displays.
MPU/ROM's and Control Board data bus.

In addition, all Address decoding between MPU and Control Board is performed in this section.

The circuits of the Device Bus Control section can be divided into the following sections:

1. Control Board Address Decoding.
2. Key Scanner Bus.
3. Latched data bus and associated devices.
4. Display Driver.
5. Keyboard Assembly.
6. Display Board Assembly.

1. Control Board Address Decoding

Address decoding for the Control Board functions is primarily undertaken on the MPU board. Secondary decoding is performed on the Control board assembly itself. Address bits A3 to A9 and A14 are passed through Latch U18 (under control of U14 on the MPU board) to Bus Driver U21, with the exception of A14 which becomes the MODE control for the display driver (described later). Decoder U17 provides Write Select signals WS1 to WS6 and the WRITE signal to the display driver.

2. Key Scanner Bus

The Key Scanner Bus merely examines the status of the Keyboard assembly to sense which of the frontpanel pushbutton or vernier keys have been selected. U20 is a BCD to decimal converter. Address lines A3, A5 and A4 (binary inputs) are incremented from one to six continuously. The decimal outputs are configured to form the vertical signal paths of the frontpanel key matrix (pushbutton and vernier), such that only one line is set low at any given time.

Meanwhile U17 (8 line to 1 line selector) selects each of its inputs individually, under control of address lines A0, A1 and A2. The eight inputs to U19 form the horizontal signal paths of the keyboard matrix, and are all individually examined each time the address to U20 is incremented. In this way, the status of data line D7 (U19 output) is always representative of the part of the keyboard matrix which has been selected for scrutiny by the address lines A0, A1 and A2 in combination with A3, A4 and A5. Therefore the MPU is always aware of which frontpanel pushbutton or vernier key (if any) has been selected.

3. Latched Data Bus and associated devices
(see Figure 8-4-1)

The latched Data bus performs three distinct functions — the devices on the bus being enabled by sub-decoder U14 (described in Service Block 3). The functions are as follows:

- i) Distribution of data on the main bus to Parameter Backlighting, Control, Mode and Unit LED's, and HP-IB Status LED's via the Keyboard Display Latches and HP-IB Latch.
- ii) Feed data from the main bus to the device bus for use by DAC's on the Control Board via the Device Bus Latch and Device Bus Transceiver.
- iii) Provide data to the numerical displays and Key LED's via the display driver (U22).

4. Display Driver

The Display Driver switches the Key, Control, Mode and Unit LED's and Digital Display in a matrix fashion, similar to the Keyscanner technique. The outputs DIG0 to DIG7 for the vertical signal paths of the matrix and the outputs a to g and DP form the horizontal signal paths as well as being routed to the individual display segments. Built into the driver is an 8 x 8 static RAM, permitting the storage of eight sets of display data at any given time.

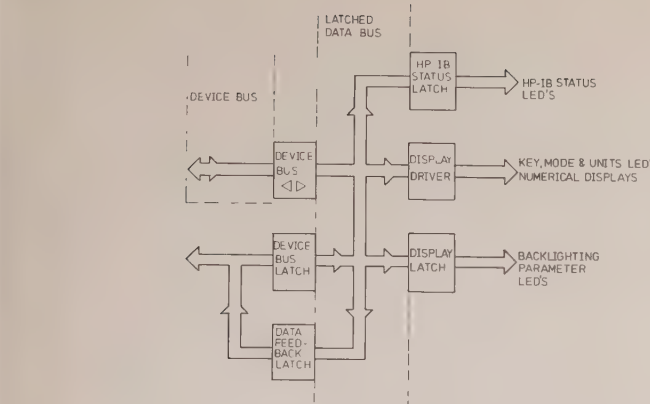


Figure 8-4-1. Latched data distribution

The control instructions are read from the bus lines if MODE is high and WRITE is low. After control instructions have been read, display data can then be written into memory with each following negative going pulse of WRITE, -MODE being low. After all eight words or digit memory locations have been written into additional transitions of WRITE are ignored. Table 8-4-1 shows control instruction definitions while figure 8-4-2 illustrates switching waveforms.

CONTROL INPUT	PIN	STATUS	FUNCTION
WRITE	8	HIGH LOW	Data not loaded into RAM Data loaded into RAM
MODE	9	HIGH LOW	Load control word on WRITE pulse. Load data on WRITE pulse.

Table 8-4-1. Display driver control instructions

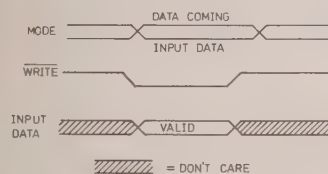


Figure 8-4-2. Display driver waveforms

5. Keyboard Assembly

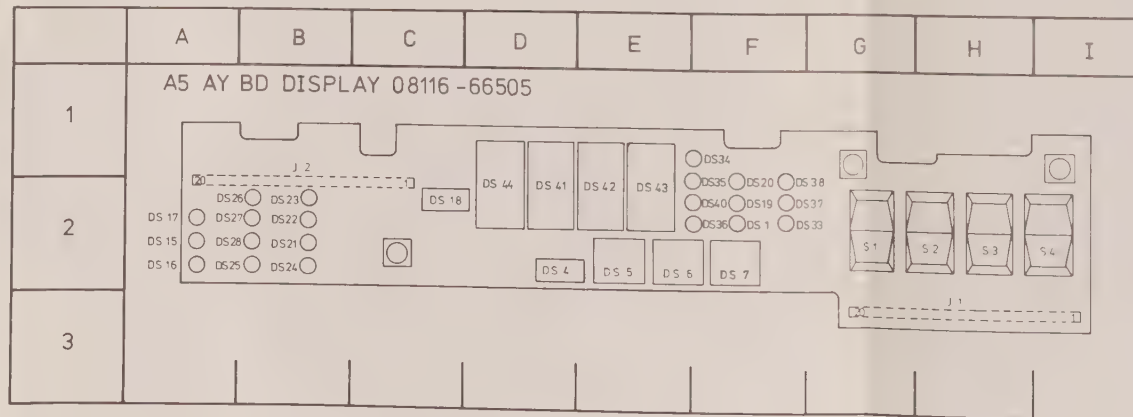
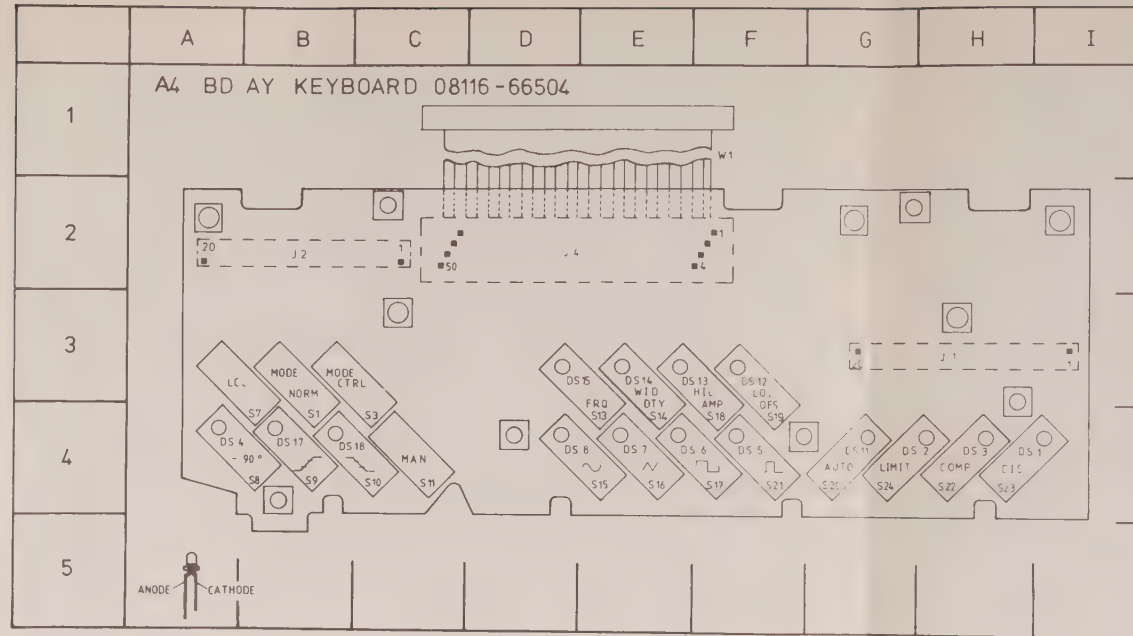
The Keyboard assembly (A4 board) is a switch panel on which all Mode, Control, Parameter, Waveform selection, Output and Trigger control pushbuttons are located. In addition, those status LED's which are housed in pushbuttons are present on this board.

As previously stated, the pushbutton key connections are matrixed with the key scanner bus, while the pushbutton status LED's are matrixed with the Display Driver bus.

6. Display Board Assembly

The Display Board Assembly (A5 board) is the panel on which the three Vernier switches and the Range switch are located. All backlighting (mnemonic) parameter LED's, Control, Mode and Unit LEDs and Alpha-numeric displays are present on this panel.

The backlighting parameter LED's are under the control of the data bus via the display latch, with the Vernier (and Range) and remaining indicators being matrixed with the key scanner bus and Display Driver respectively.



COMP	REF	COMP	REF
DS1	I4	S7	A3
DS2	H4	S8	A4
DS3	H4	S9	B4
DS4	A4	S10	B4
DS5	F4	S11	C4
DS6	E4	S13	E3
DS7	E4	S14	E3
DS8	D4	S15	D4
DS11	G4	S16	E4
DS12	G3	S17	E4
DS13	F3	S18	F3
DS14	E3	S19	F3
DS15	E3	S20	G4
DS17	B4	S21	F4
DS18	B4	S22	H4
J1	H3	S23	I4
J2	B2	S24	G4
S1	B3	W1	D/E1
S3	C2		

COMP	REF	COMP	REF
DS1	F2	DS36	F2
DS5	E2	DS37	F2
DS6	F2	DS38	F2
DS7	F2	DS39	F1
DS15	A2	DS40	F2
DS16	A2	DS41	D2
DS17	A2	DS42	E2
DS18	C2	DS43	E2
DS19	F2	DS44	D2
DS20	F2	J1	H3
DS25	A2	J2	B2
DS26	A2	S1	B2
DS27	A2	S2	H2
DS28	A2	S3	H2
DS29	B2	S4	I2
DS30	B2		
DS31	B2		
DS32	B2		
DS33	F2		
DS34	F1		
DS35	F2		

Pin No.	U14	U19	U20
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			

Table 8-5-3. Frequency Range Corrections

NOTE: Q0 is only used when the result of $\frac{HIL - LOL}{2}$ is an odd number (0.5 mV correction)

AMP 100 mV

Verify correct operation of U31 by setting 8116A to "E.WID" and "Sine". U31 pin 3 must deliver a signal with a frequency of approx. 100 Hz.

NOTE: LAYOUT FOR OPT. 001
A2 CONTROL BOARD 08116-66512
IS ON SHEET 8 (PAGE 8-20)

CONTROL 5

SERVICE BLOCK 5

CONTROL THEORY OF OPERATION

Introduction

The 8116A Control section is located on A2 Control Board assembly. Power supplies to the board are via A1 Main board assembly and data and control signals are supplied from A3 MPU board assembly.

The Control section can be divided into specific areas and are discussed as follows:

Byte Offset latches and Offset DAC Timer.
Address Decoding.
Reference circuit.
D to A Converters.
Width Vernier Current Source.
Up and Down Current Source.
Capacitance Amplifier.

Byte Offset Latches and Offset DAC

Because it is necessary for the analog Amplitude and offset values to be available simultaneously, and because the Offset DAC has no internal latches, the high and low Byte Offset latches have been designed into the circuit discretely.

Data from the Latched Data Bus on the MPU Board A3 (see Schematic 4) arriving at U21 and U23 is latched through the devices on receipt of the negative going edge of $\overline{HBO}$ from decoder U14, and presented to latches U22 and U43. The data is further latched to the inputs of DAC U24 on receipt of the negative transition of SCA. The time difference between SCA (enabling the amplitude DAC) and SCA is merely the propagation delay through buffer U19.

The Offset DAC itself is a 12-bit multiplying device, providing two current outputs. Iout1 (pin 1) is active when any combination of the twelve digital inputs are high, and the summed currents derived from the reference voltage via selected $R/2R$ networks are available at this point. Iout2 (pin 2) provides current from the remainder of the reference voltage via those $R/2R$ networks which have not been selected (data inputs low). Thus, the algebraic sum of current derived from the reference voltage is equal to the sum of Iout 1 and Iout 2, where Iout 1 represents data inputs selected and Iout 2 represents data inputs not selected.

When Offset is selected by the operator at the instrument frontpanel, the resulting digital signal, derived from LD7 is used to enable the output of the Offset DAC via switch U17.

Note:

U17 on when ofs = 999 mV (for ampl. of = 100 mV)
= 99.9 mV (for ampl. of < 100 mV)

Timer

The IC which is responsible for this task is a standard type 555, and is configured to behave as an Astable multivibrator — dependent upon two different signals for free-run operation.

The logic signal arriving at pin 4 from NAND gate U40, is required to be high in order for the Astable to run. When this input is low, the timer is effectively inhibited. The other signal required is RESET, which also needs to be high.

The Timer output is at pin 3 ($\overline{NMI}$) — a signal required by the MPU to produce the flashing error display.

Address Decoding

Address Decoding is performed by U14 and U20. Address lines LA3, LA4 and LA5 from the MPU board comprise the input address to both decoders — the output line selected being dependent upon binary value of the input.

Reference Circuit

The -9 V reference voltage provides a constant current and is derived from a unity-gain inverting amplifier. The -9 V supply is used as a reference by the Amplitude, Offset and Width Vernier Current Source DAC's on the Control Board.

Digital to Analog Converters

Figure 8-5-1 shows three channels of a basic DAC. Switches A, B and C correspond to digital inputs — A being most significant, B the second significant and C third most significant. In the diagram the position of the switches is related to a logic high input, i.e. all three bits ON.

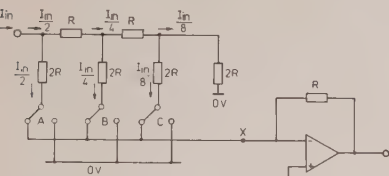


Figure 8-5-1. DAC — principle of operation

The total current I_{in} , which is derived from the reference voltage, is divided by a factor of two for each resistance path it meets. The currents are then summed at point X such that, in this case, the total current available is:

$$I_{in}/2 + I_{in}/4 + I_{in}/8 = 7/8 I_{in}$$

By selecting any combination of the three digital inputs, output currents between $1/8 I_{in}$ to $7/8 I_{in}$ may be output. In practice, DAC's generally have 8, 10 or 12 digital inputs. In this case, the reference current is divisible by up to 256, 1024, and 4096 respectively.

When a logic low level is applied to an input, the current through that particular channel continues to flow, but to ground. The remainder of the current derived from the reference voltage is buffered and inverted before being passed on to the load.

The Control Board Amplitude and Frequency DAC's function in the above fashion.

To describe the operation of the remaining DAC's it is necessary to refer to Figure 8-5-2. As in the previous description, inputs are selected digitally, with each channel dividing the current to half the preceding channel's value. The difference in the circuits is that in the second example, the output is a reciprocal value of the selected inputs. The currents being summed at the inverting input of the op-amp can be expressed as:

$$VA/2R + VA/4R + VA/8R = -V_{ref}/R$$

$$\text{therefore, } VA = -8/7 V_{ref}$$

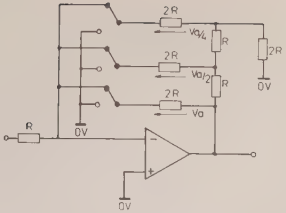


Figure 8-5-2. DAC — reciprocal operation

The Control Board Width Vernier Current Source and Duty Cycle DAC's function in the above manner.

Width Vernier Current Source

The operation of the DAC in this circuit is described above. The reciprocal output current is drawn through one of two resistance paths, selectable logically, and then passed to the Analog Decoder section of the Timing IC on Main Board Assy A1.

Up and Down Current Sources

Both current source outputs are dependent upon the Duty Cycle DAC outputs. The frequency DAC output, after being attenuated, provides the reference inputs for both Duty Cycle DAC's. DAC U8 output is directly proportional to the duty cycle selected, while U10 output is proportional to the difference between Period and Duty Cycle. Therefore, both outputs, if added together, represent the programmed period of the waveform selected.

The outputs of the Up and Down Current Sources obey the same rule. When a Duty Cycle of 50 % is selected both Source outputs will be identical. If, however, a duty cycle of 20 % is selected, the ratio of output currents will be 80 % to 20 % in favour of the Up Current Source. This apparent inversion ratio is due to the reciprocal output of the Duty Cycle DAC's. The requirement of the Slope Generator is such that for a short duty cycle, the ramp capacitor has to charge more quickly than for a long duty cycle. This being the case, more current is made available for a fast charge time than for a slower charge time.

Model 8116A

Capacitance Amplifier

The operation of the capacitance Amplifier is best explained with the aid of Figure 8-5-3 and 8-5-4.

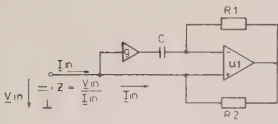


Figure 8-5-3. Simplified capacitance amplifier

Figure 8-5-3, illustrates a simplified capacitance amplifier circuit. U1 serves merely as a voltage amplifier. For the purposes of a basic description however, Figure 8-5-4 is provided.

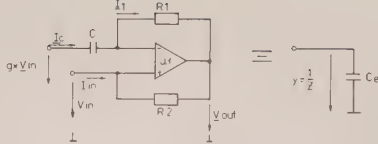


Figure 8-5-4. Formula derivation for capacitance amplifier

The capacitance amplifier is basically a circuit in which a capacitor's value may be increased or decreased in decade ranges. The effective capacitance may be represented by the Formula:

$$C_e = \frac{R1}{R2} (g-1) C, \text{ uF}$$

Where R1 is the resistance in the negative feedback path, R2 is the resistance in the positive feedback path, g is the gain of the voltage amplifier and C is the value in microfarads of the circuit capacitor. By varying the value of R1, the equivalent output capacitance will also vary.

In the instrument, the decade resistors are switched in to the circuit digitally via latch U3 and relays K1 to K4.

The amplifier output is passed to the Range Switching circuit on Main Board Assy A1 (see Service Block 6 for details).

SERVICE BLOCK 6

VCO, WIDTH GENERATOR THEORY OF OPERATION

General

The bulk of the Slope Generation and Timing circuitry is to be found on the Main Board A1 Assy. A small part is also located on Control Board A2 Assy.

The Overall operation may be generally divided into the following functions:

- 1. Trigger Input Circuits
- 2. Control Input Circuits
- 3. Slope Generator IC
- 4. Timing IC
- 5. Error Feedback and Vernier Feedback

1. Trigger Input Functions

There are three distinct trigger input functions.

The first stage (Trigger Level Circuit) receives both the trigger input and trigger level adjust directly from the instrument frontpanel, and is designed to provide the required trigger level to the second stage without imposing it on the trigger input signal (thereby not disrupting the trigger source). Figure 8-6-1 shows the principle of operation of the circuit. Op-Amp U101A is configured to provide a fixed voltage source of -1.25V, and U101B is an inverting amplifier of unity gain used to provide a voltage of equal magnitude but opposite polarity to the level selected.

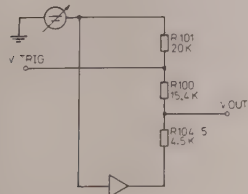


Figure 8-6-1. Trigger input circuit simplified

By varying the voltage across the divider chain, the DC component (or DC shift) of Vout will change accordingly. Vout is now passed through high-to-low impedance converter Q100/Q101 and on to the second trigger output function. The trigger input amplifier is a three-stage ECL circuit with Schmitt trigger characteristics. Each operational amplifier stage has a main and complementary output — both of which are pulled down to -5.2 V via a 470 Ohm resistor. The circuit feedback resistor (R113) provides a hysteresis path to the input in order to overcome any noise which may be present. The threshold of this Schmitt Trigger circuit is fixed at -1.3 V. The third trigger input function is a wired-OR configuration for trigger slope/MAN selection. INT BURST or MAN selection at the frontpanel results in the Trigger Mode Latch U103 outputting a TTL high to one of four ECL NOR gates via the TTL/ECL converter R116/R117/R118. In the wired-OR configuration, a logic high prevails (logic low is, in fact, a high impedance output stage). Auto Vernier FF U203 is clocked by this high-going signal, eventually providing an Auto Vernier Feedback signal, after having been reset as a result of Auto Vernier selection at the frontpanel.

2. Control Input Circuits

The control input signal from the instrument frontpanel is routed to the Main Board A1 Assy. The circuit input has voltage protection diodes CR151 and CR152 to clamp incoming levels outside the ± 15 V window. Operational amplifier U151 is configured as a unity-gain, non-inverting buffer — the output being limited within a -5.2 V to +5 V window — which provides the input to the Control Mode Selector U152. Frequency and Amplitude Modulation, Pulse Width Modulation and Voltage controlled oscillator modes are selected via logic signals M1 and M2 at U152. For FM mode, the control signal is output from U152 pin 14. VCO mode control signal is output at pin 12, and PWM control signal at pin 4 (via pin 11). When AM has been selected, U152 pin 13 becomes earthed via pin 15, and U151 output is processed by the Amplitude modulator. See Service Block 7.

The PWM control signal is passed from the selector directly to the Timing IC (U300), which is used as a width generator. Further information about this IC appears in this Service Block.

The VCO and FM control signals are discussed further in Service Block 5.

3. Slope Generator IC (U201)

The Slope Generator here functions as triangle waveform generator up to 50 MHz. The signal generation may be free-running, gated or triggered. A special burst control input — Burst control — (pin 2) permits a counted number of pulses to be generated on receipt of a trigger signal derived from the Burst Counter on A2 Control Bd Assy. Figure 8-6-2 shows a block diagram of the Slope Generator IC.

Generation of the triangular waveform is achieved by charging and discharging a ramp capacitor with constant current. External current sources are used for this task.

Current sources

For repetition rate generation, the Slope Generator I.C. relies upon the Ramp Current Source for charging a range capacitor (internally or externally), and I_{dn} REF for discharging.

The ramp current source is derived from I_{up} REF, and passed through complementary transistors Q203 and Q204. While charging, current is drawn through Q203 — under control of the internal buffer. When the capacitor charge threshold has been attained Q203 is switched off, ramp current is dumped to ground via Q204 and the capacitor discharged through I_{dn} REF. This principle applies to variable Duty cycles. I_{up} REF is utilised when variable start phase has been selected in TRIG, GATE or BURST mode. The level at which the capacitor begins to charge is fixed by two clamping diodes acting upon a voltage at pin 11.

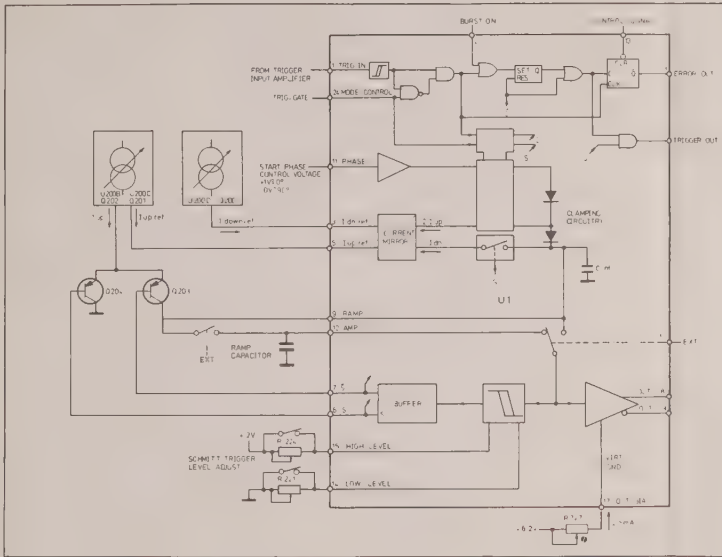


Figure 8-6-2. Slope Generator block diagram

This voltage is derived from the Reference circuit and has a different value for each start phase. I_{up} REF has no effect when the instrument is in Normal mode. Table 8-6-1 shows the relationship between clamped voltage and start phase.

Pin 11	start phase
0 V	-90°
1 V	0°

Table 8-6-1.

The current source is required to sink 2xI_{up} (Phase voltage source pin 11, and I_{up} REF) in order to balance the two clamping diodes during the time when the oscillator is not running e.g. between gate signals.

In the external range switching circuit, current values are variable by up to a factor of 100, and the capacitors arranged in parallel decade multiples (digitally controlled from Range Latch U210). Frequencies from 1 MHz to 1 MHz with variable duty cycles from 10 % to 90 % are possible. For frequencies less than 10 Hz a special capacitance amplifier is necessary to provide the high capacitance values which are needed for very low frequency generation. The function of this capacitance amplifier is described in Service Block 5.

Schmitt Trigger

The Slope Generator IC has a Schmitt Trigger which controls the switching of analog circuitry within the device.

The upper and lower switching thresholds for the Schmitt Trigger are defined externally in the High and Low level adjust circuits. The actual threshold voltage will depend upon the state of switches U205.

A reference voltage of 6.2 V is divided down to approximately 1.9 V, then passed to U202A. Switch U205 is digitally controlled from Range Latch U210, its wiper position being dependent upon the frequency range selected. Table 8-6-2 shows the relationship between frequency ranges and Range Latch data to U205.

EXT	R3	Range
1	0	1 MHz — 999 kHz
1	1	1 MHz — 9.99 MHz
0	1	10 MHz — 50 MHz

Table 8-6-2. Relationship between frequency and latch data

The resulting voltage is passed to the Schmitt Trigger as the high level threshold. The low level threshold is derived in the same way as above with the exception of the reference voltage being 0 V in this case.

The values of the currents drawn by the Schmitt Trigger are always proportional to the I_{up} REF value in order to compensate for propagation delays encountered in the Schmitt trigger and current switching circuits.

In Burst mode, a selectable number of triangles or square-waves are generated at the I.C. output, the selected number being loaded into a counter (see Service Block 8 for details). The counter consists of 11 stages to enable selection of any number between 1 and 1999. Upon the burst start trigger, the counter, having been pre-loaded, counts down to 1. The value "1" is used to detect burst completion to generate a disable signal, which together with the last oscillator output pulse disables the gate input and reloads the burst number into the counter. The next burst cycle is then triggerable almost immediately.

Figure 8-6-3 shows the relationship between external triggering and start phase.

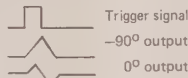


Figure 8-6-3a



Figure 8-6-3b

Error output

The Error output of the Slope Generator I.C. is used only for instrument self-test purposes.

4. Timing IC

The Timing IC performs three distinct functions:

- a. Triggerable pulse width generator.
- b. Pulse Width Modulation as a result of an external control input (at the instrument frontpanel).
- c. A trigger source for the Internal Burst mode.

The various operating modes for the IC are designated TIME, RATE and PWM.

In TIME mode the width of the output pulse is variable over 8 decades between 10 ns and 999 ms (see Table 8-6-3). Analog control within each decade is achieved by varying the FREQ IN current at pin 4. Control current is derived from the Width DAC on bd A2. In RATE mode the output frequency is variable over 8 decades from 1 Hz to 100 MHz. However, the fastest range is not fully utilised. To understand the method of frequency division in the IC it is necessary to refer to the block diagram. It will be seen that, in addition to a 6 decade counter, there is an analog divide-by-5 current attenuator and a flip-flop (divide-by-2). The control current from the Width Vernier Current DAC on bd A2 is varied at the FREQ IN port at pin 4.

Because FREQ IN and TIME IN are virtual ground inputs, a voltage source and series resistor provide the external current.

The approximate value of current taken in each of the input modes is shown in table 8-6-3.

	REF CURRENT	FREQ IN	TIME IN
RATE mode	~ 80 uA	2 mA - 0.2 mA	0.2 mA const
TIME mode	~ 80 uA	2 mA - 0.2 mA	0.2 mA const
PWM	~ 80 uA	2 mA const	2 mA - 0.2 mA

Table 8-6-3. Mode/Current relationship

Note that the first input stage performs an IFREQ/ITIME function.

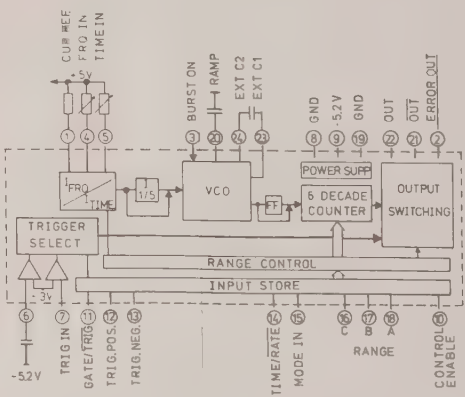


Figure 8-6-4. Timing I.C. block diagram

The VCO operates in 2 ranges. In TIME mode the ranges are 10 ns to 99.9 ns and 50 ns to 500 ns.

In RATE mode the ranges are 100 MHz to 10 MHz and 20 MHz to 2 MHz. For all lower ranges in each mode, the 6-decade counter is used.

Table 8-6-5 illustrates frequency range selection.

The Timing IC has a built-in input store which is fed digitally by 8 Mode and Range select lines from the A3 uP board.

Taking these inputs in numerical pin sequence, their functions are as follows:

Pin No.	Signal	Function
10	WS3	Control Enable. A TTL positive-going edge on this pin latches all digital information into the input store.
11	LD7	These three inputs determine the Timing IC trigger modes.
12	LD6	
13	LD5	
14	LD4	Mode select (TIME, RATE). See Table 8-6-4.
15	LD3	
16	LD2	Range selection, Width in Time mode and Frequency in Rate mode. See table 8-6-5 for details.
17	LD1	
18.	LD0	

TIME	MODE IN	MODES	OUTPUT
0	0	RATE	RATE
0	1		NOT USED
1	0	TIME	TIME
1	1		NOT USED

Table 8-6-4. Mode selection truth table

RANGE #	RANGE C	RANGE B	RANGE A	OUT FREQ IN RATE MODE	OUT WIDTH IN TIME MODE
0	0	0	0	10 ⁷ - 10 ⁸ Hz	10 ⁻⁸ - 10 ⁻⁷ sec
1	0	0	1	10 ⁶ - 10 ⁷ Hz	10 ⁻⁷ - 10 ⁻⁶ sec
2	0	1	0	10 ⁵ - 10 ⁶ Hz	10 ⁻⁶ - 10 ⁻⁵ sec
3	0	1	1	10 ⁴ - 10 ⁵ Hz	10 ⁻⁵ - 10 ⁻⁴ sec
4	1	0	0	10 ³ - 10 ⁴ Hz	10 ⁻⁴ - 10 ⁻³ sec
5	1	0	1	10 ² - 10 ³ Hz	10 ⁻³ - 10 ⁻² sec
6	1	1	0	10 ¹ - 10 ² Hz	10 ⁻² - 10 ⁻¹ sec
7	1	1	1	10 ⁰ - 10 ¹ Hz	10 ⁻¹ - 10 ⁰ sec

Table 8-6-5. Range selection

The output switching block of the Timing IC provides three signals, two of which are differential open collector outputs (OUT at pin 22 and OUT at pin 21). The two differential open collector outputs have fixed risetime and current amplitude of 12 mA. The third output signal is the ERROR OUT signal at pin 12, which indicates a timing error if a trigger signal occurs before the previously begun event has been completed (see Figure 8-6-5). Also, the Error Output is used during self-testing. The ERROR OUT port is an open collector configuration with fixed current swing.

5. Error Feedback and Vernier Feedback

These are two sources of error in circuits covered by this service block. The first is the WIDTH ERROR signal from the Timing IC-previously mentioned in (4). The second error is VCO ERROR, which is output from the Slope Generator IC at pin 23 when the circuit is triggered before the previously begun cycle is completed. VCO ERROR is utilised only for instrument Self-Test purposes and is software controlled.

Both error signals, at source, are ECL. Transistors Q302 and Q303, diodes CR301 and CR302 and resistors R118 and R129 make the error signals TTL compatible before they perform a Set function on Flip-Flops U301A and U301B. The Flip-Flop outputs are then gated with RSA before being put on the data bus.

The Auto Vernier feedback signal which accomplishes the Auto Vernier function is derived from the Trigger circuitry and also made TTL compatible before being output to the data bus.

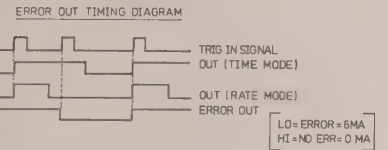


Figure 8-6-5. Error output waveforms

SERVICE BLOCK 6 TROUBLESHOOTING GUIDE

Control Mode	M3	M2	M1	Freq. Range	Frequency	EXT	EXT	R3	R4	R5	R6	R7	LFR
off	L	H	L	1	10.0 MHz - 50.0 MHz	L	H	H	H	H	H	H	H
FM	L	L	H	2	1.00 MHz - 9.99 MHz	H	L	H	H	H	H	H	H
AM	H	H	L	3	100 kHz - 999 kHz	H	L	H	H	H	H	H	H
PWM	L	H	H	4	10.0 kHz - 99.9 kHz	H	L	L	H	H	H	H	H
VCO	L	L	L	5	1.00 kHz - 9.99 kHz	H	L	L	L	H	H	H	H
				6	100 Hz - 999 Hz	H	L	L	L	L	L	H	H
				7	10.0 Hz - 99.9 Hz	H	L	L	L	L	L	L	H
				8	1.00 Hz - 9.99 Hz	H	L	L	L	L	L	L	L
				9	100 mHz - 999 mHz	H	L	L	L	L	L	L	L
				10	10.0 mHz - 99.9 mHz	H	L	L	L	L	L	L	L
				11	1.00 mHz - 9.99 mHz	H	L	L	L	L	L	L	L

Control mode truth table

Table 8-6-5 (A) Range selection

Waveform	Mode	WF2	WF1
1, BUR		L	L
all, except E.WID		L	H
all, except E.WID		L	H
E.WID		H	L
all, except E.WID		H	H

Table 8-6-6. Logic signals information

VCO TROUBLESHOOTING

8116A Setting:

MODE NORM
OUTPUT sine
FRQ 1.00 kHz
DTY 80 %

Schmitt Trigger Low and High Levels

For frequencies to 999 kHz, the Schmitt trigger levels are set at 0 V for the low level (U201 / pin 14) and +2 V for the high level (U201 / pin 15).

If the levels are incorrect, disconnect U201 from its socket and recheck voltages at socket pin 14 and 15.

To disconnect U201, turn instrument off. When instrument is turned on again with disconnected U201, error E21 occurs in the display. Press LCL key to set 8116A to normal operation routine.

Check analog switch U205 against table 8-6-7.

Frequency Range	R3	EXT	"ON" Channels			
			pin	pin	pin	pin
1.00 mHz - 999 kHz	L	H	2 -> 3	15 -> 13		
1.00 MHz - 9.99 MHz	H	H	4 -> 3	11 -> 13		
10.0 MHz - 50.0 MHz	H	L	5 -> 3	14 -> 13		

Table 8-6-7. U205 truth table

Iup Current Source (U200B, Q202)

Set 8116A:

MODE NORM
FRQ as required
DTY 50 %

Connect a current meter between U201 pin 9 and ground. Check values against table 8-6-8.

FRQ	Current ± 10 %
1.00 kHz	0.165 mA
5.00 kHz	0.830 mA
9.99 kHz	1.650 mA

Table 8-6-8. Iup-, Iupref- and Ildnref currents (50 % Duty Cycle)

Iup ref Current Source (U200C, Q201)

Iup ref current is used to provide the start phase clamping in Trigger, Gate and Burst Modes.

It may only be checked when U201 is disconnected from its socket (same setting as for Iup Current Source).

For disconnection of U201 turn instrument off. When instrument is turned on again with disconnected U201, error E21 occurs in the display. Press LCL key to set 8116A to normal operation routine.

Connect current meter between U201 socket pin 5 and ground. Check current values against table 8-6-8.

Ildn ref Current Source (U200D, Q200)

Same procedure as above.

Connect current meter between U201 socket pin 3 and ground.

WIDTH Generator - Troubleshooting

8116A Setting:

MODE NORM
OUTPUT pulse
FRQ 100 kHz
WID 6.00 us

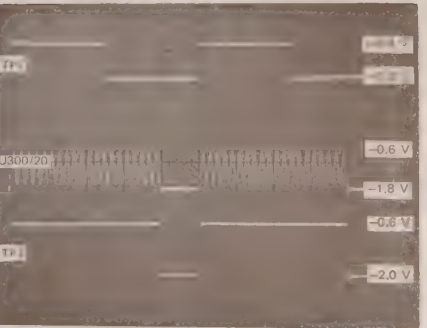


Figure 8-6-7. Width Generator Input and Output Signals

NOTE: When measuring at U300 pin 20, width may change due to the capacitance of the probe.

WIDTH Vernier Current

The width vernier current can be checked by measuring the voltage at R308/C303. (Table 8-6-9).

Set 8116A:

MODE NORM
OUTPUT pulse
FRQ 1.00 kHz
WID as required

Width	Voltage at R308/C303	
	min	max.
10.0 us	80 mV	180 mV
99.9 us	1.16 V	1.80 V

Table 8-6-9.

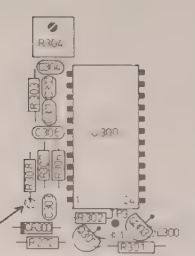


Figure 8-6-8. Width Vernier Control Voltage

Verify that voltage at U300 pin 4 is held at virtual ground (min. -40 mV; max. 0 mV). Verify that also U300 pin 1 and U300 pin 5 are at virtual ground (min. -40 mV; max. 0 mV).

Trigger Level Circuit/Input Amplifier

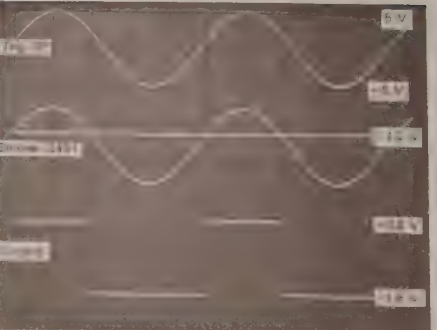


Figure 8-6-9. Trigger Input Amplifier Signals

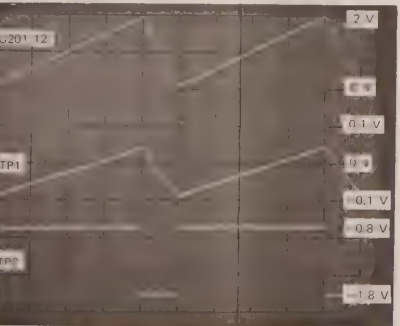
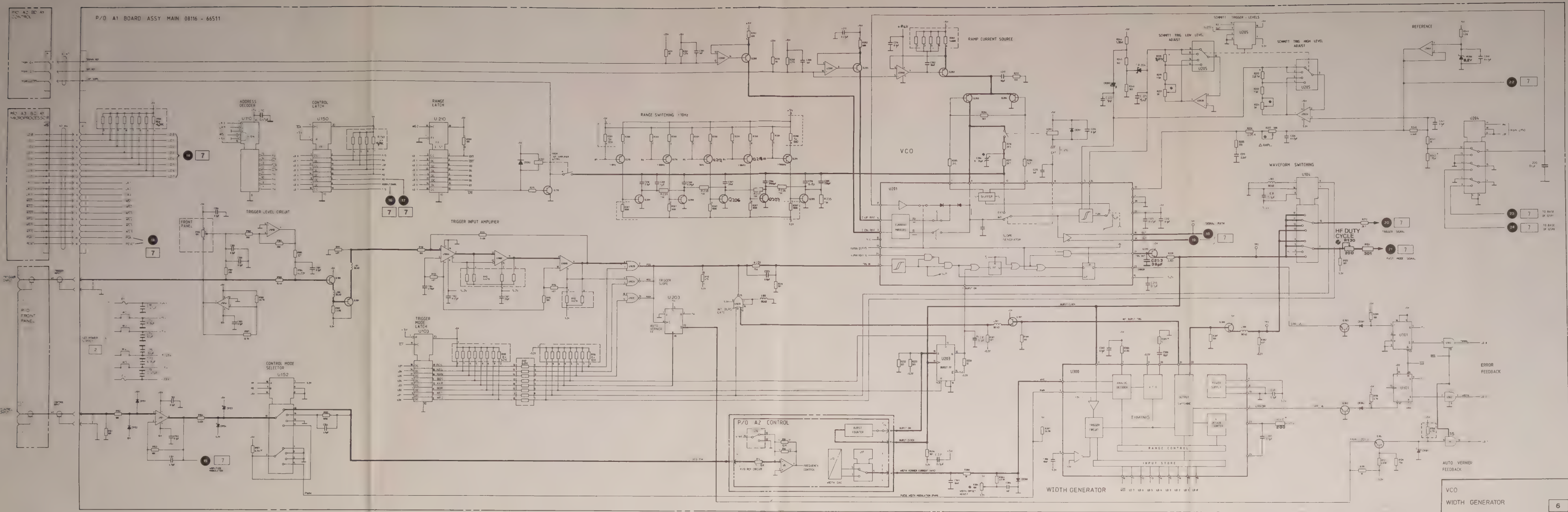


Figure 8-6-6. VCO Input and Output Signals

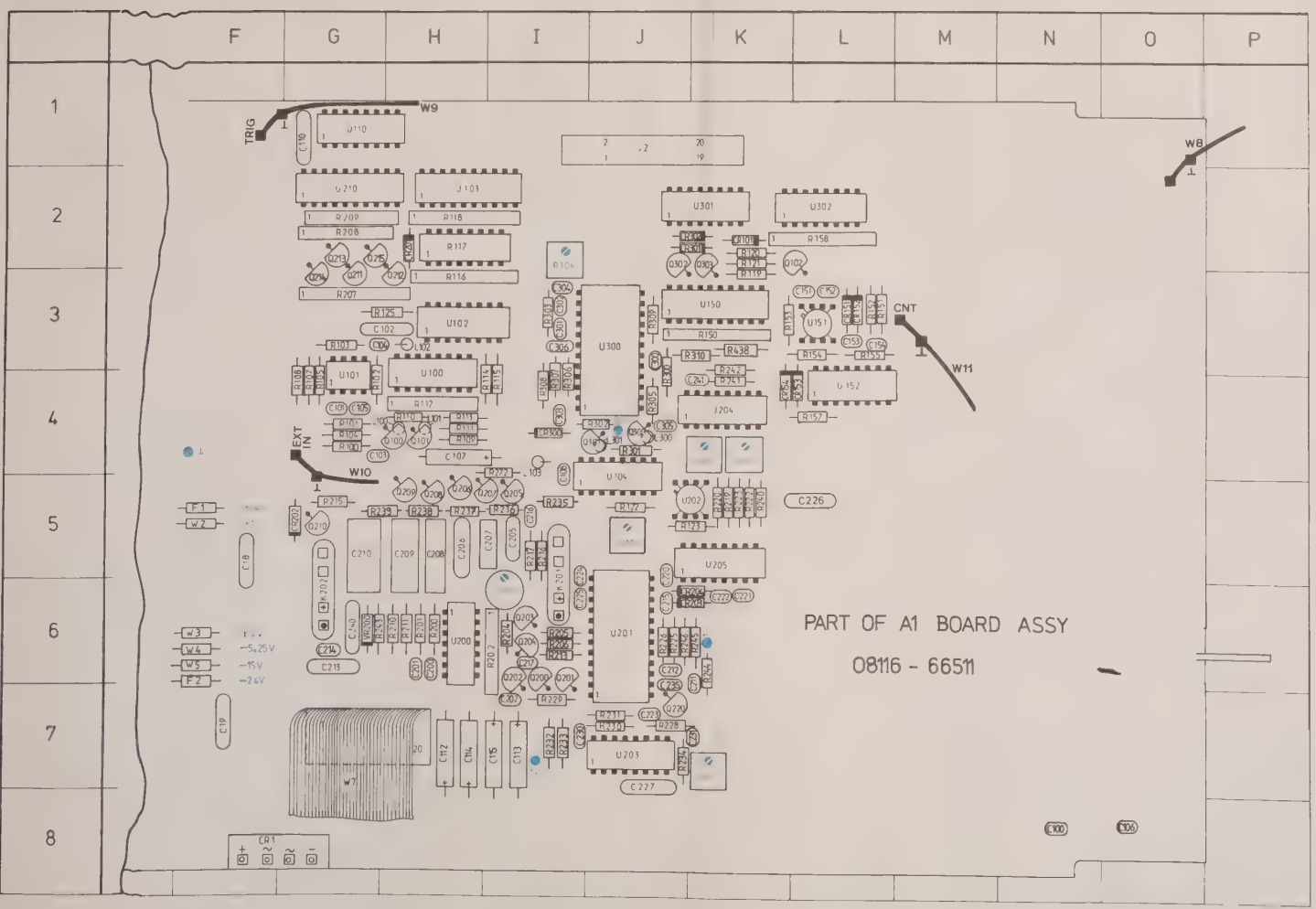
NOTE: Signal at TP1 may not necessarily be symmetrical.

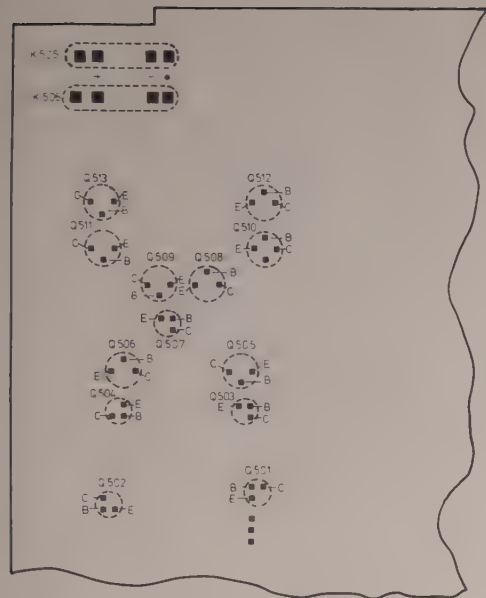


TROUBLESHOOTING GUIDE

Logic Signals — Abbreviations — Description	
Address Decoder U110	LA3 LA4 WS1
Control Latch U150	CLT CLR CLM
Range Latch U210	WS2 EXT EXT R3 R4 R5 R6 R7 LFR
Trigger Mode Latch U103	CLT POS NEG MAN BOS AVR BOR WF1 WF2
Timing IC U300	LD7 LD6 LD5 LD4 LD3 LD2 LD1 LD0
Error Feedback U301/U302	RSA CLR

NOTE: If an error code is shown in the display it is necessary to press a key, e.g. LCL, to set the u-Processor to normal routine, then troubleshoot the instrument.

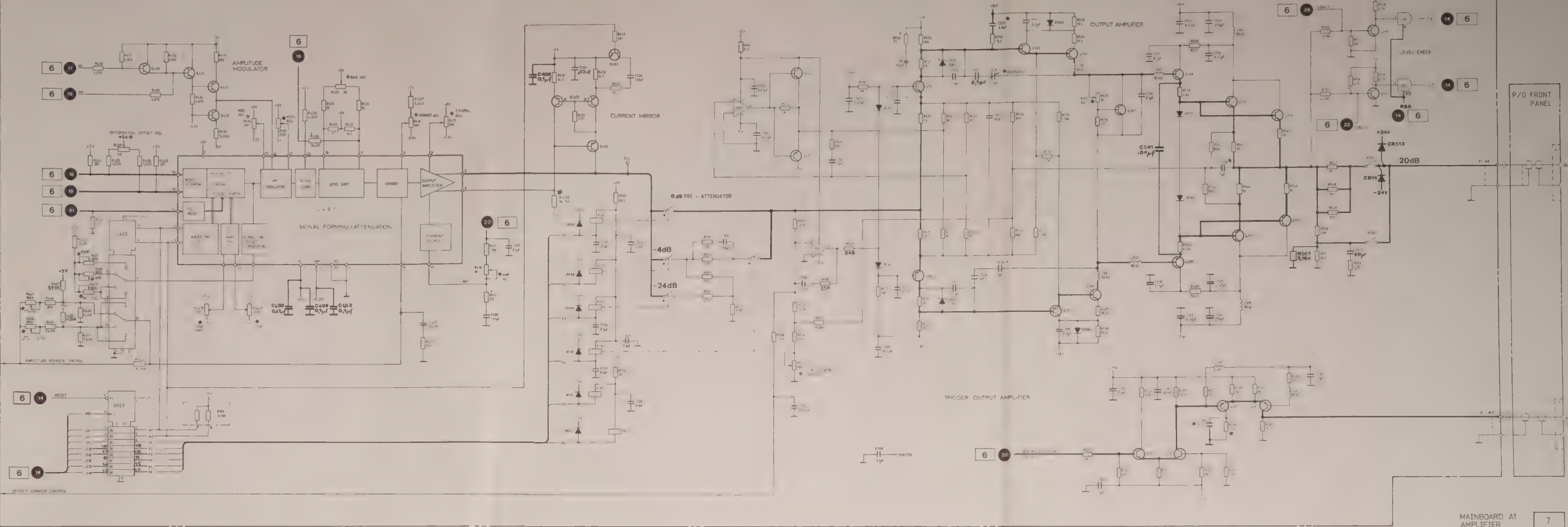




P/O A1 Layout Underside

P/O A1 BD AY
CONTROL

P/O A1 BOARD ASSY MAIN 08116-66511



MAINBOARD A1
AMPLIFIER

SERVICE BLOCK 7 TROUBLESHOOTING GUIDE

NOTE: If an error code is shown in the display it is necessary to press a key, e.g. LCL, to set the u-Processor to normal routine, then troubleshoot the instrument.

8116A Setting:

MODE NORM
FRQ 1.00 kHz
AMP 999 mV; 9.99 V; 16.0 V
OUTPUT triangle



Figure 8-7-3. Shaper IC output signals

NOTE: U401/18 & 19 signals may not necessarily be symmetrical.

8116A Setting:

MODE NORM
FRQ 1.00 kHz
AMP 999 mV; 9.99 V; 16.0 V
OUTPUT pulse or square

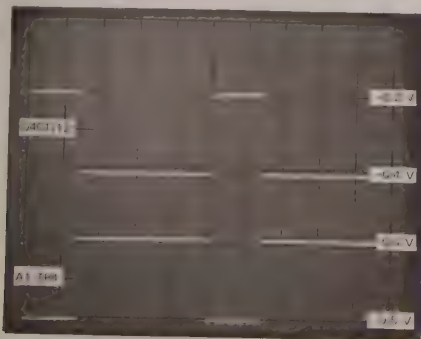


Figure 8-7-4. Shaper IC input and output signals

Amplitude Vernier Control Voltage

8116A AMPLITUDE	Voltage at R422/R450 ± 10 %
1.00 V	7.95 V
5.00 V	4.40 V
9.99 V	0.00 V

Table 8-7-1. Offset ... 000 mV

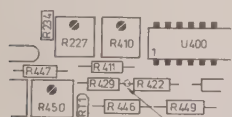


Figure 8-7-5. P/O A1 Layout

Shaper IC Reference Current

Remove U401 from its socket and measure the current from socket pin 16 to gnd. It should be approximately 2.5 mA.

Before removal of U401 turn instrument off. When instrument is turned on again with removed, an U401 error E51 occurs in the display. Press LCL key to set 8116A to normal operating routine.

Current Mirror

To confirm correct operation check that the signal levels at Q401A and Q401B emitters are identical (the transistors are a matched pair).



Figure 8-7-6. Q401 Bottom View

Pre-Attenuator, Output Attenuator

Amplitude Range	K1	K2	K3	K4	K5	K6
10.0 V - 16.0 V	L	H	H	H	X	H
1.00 V - 9.99 V	H	L	H	L	X	H
100 mV - 999 mV	H	H	L	L	X	H
10.0 mV - 99.9 mV	H	H	L	L	X	L
Waveform off (> 100 mV) only	H	H	L	L	X	L
DISABLE	H	X	X	X	H	H

Table 8-7-2.

Offset Vernier Control Voltage

8116A Offset	R508/C501
7.95 V	+3.20 V
-5.00 V	+2.00 V
000 mV	0.00 V
+5.00 V	-2.00 V
+7.95 V	-3.20 V

Table 8-7-3. Amp ... 100 mV

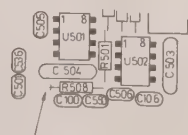


Figure 8-7-7. P/O A1 Layout

Output Amplifier

The following hints will help to isolate a fault in the 8116A output amplifier.

CAUTION

Do not operate without heat sinks on board A1. If replacement of one of the transistors Q505-Q513 is necessary, first remove all heat sink securing screws, then plate or bracket and finally, if necessary, the transistor adaptors. Do not attempt to remove a complete heatsink assembly i.e. plate and transistor adaptors together since damage to transistors will be likely.

Set 8116A:

Waveform off
Offset 0.00 V

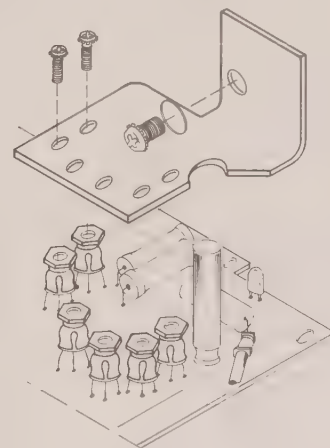


Figure 8-7-8. Heat Sink Removal

Check voltage between CR501 and CR502. If it is fully negative (approx. -15 V) check U502, Q502, Q504 and Q506. If it is fully positive (approx. +15 V) check Q501, Q503 and Q505 and also U502.

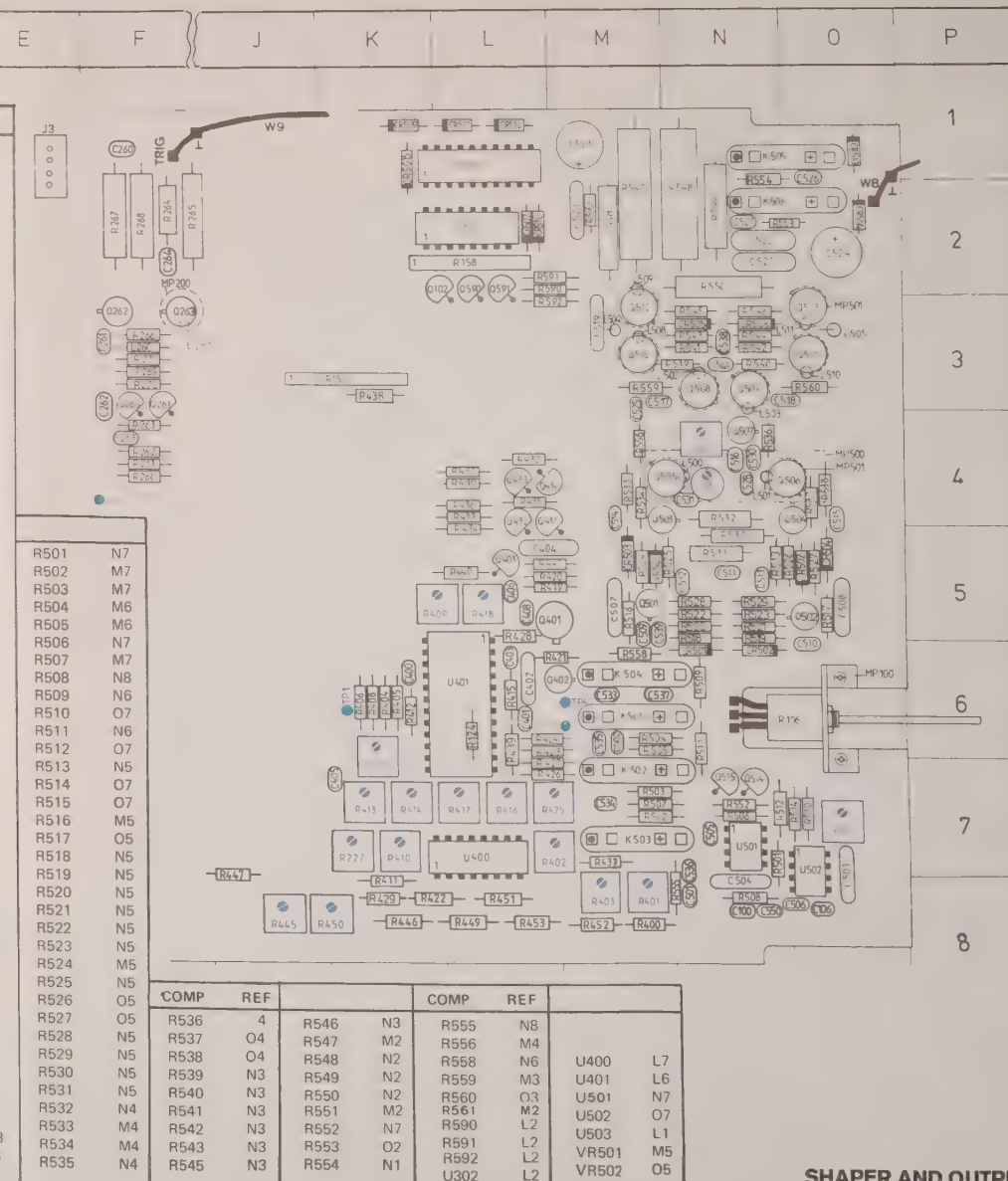
If Q510/511 or Q512/513 fail (emitter/collector short circuit) the +24 V, -24 V Power rail fuses F1 and F2 will blow. If it is necessary to replace any of the output stage transistors Q508-Q513, check that CR505 and CR506 are not defective. They protect the output stage when high amplitude and high frequencies are required by discharging the base/emitter capacitance of Q510-Q513.

Distorted Leading and Trailing Edges

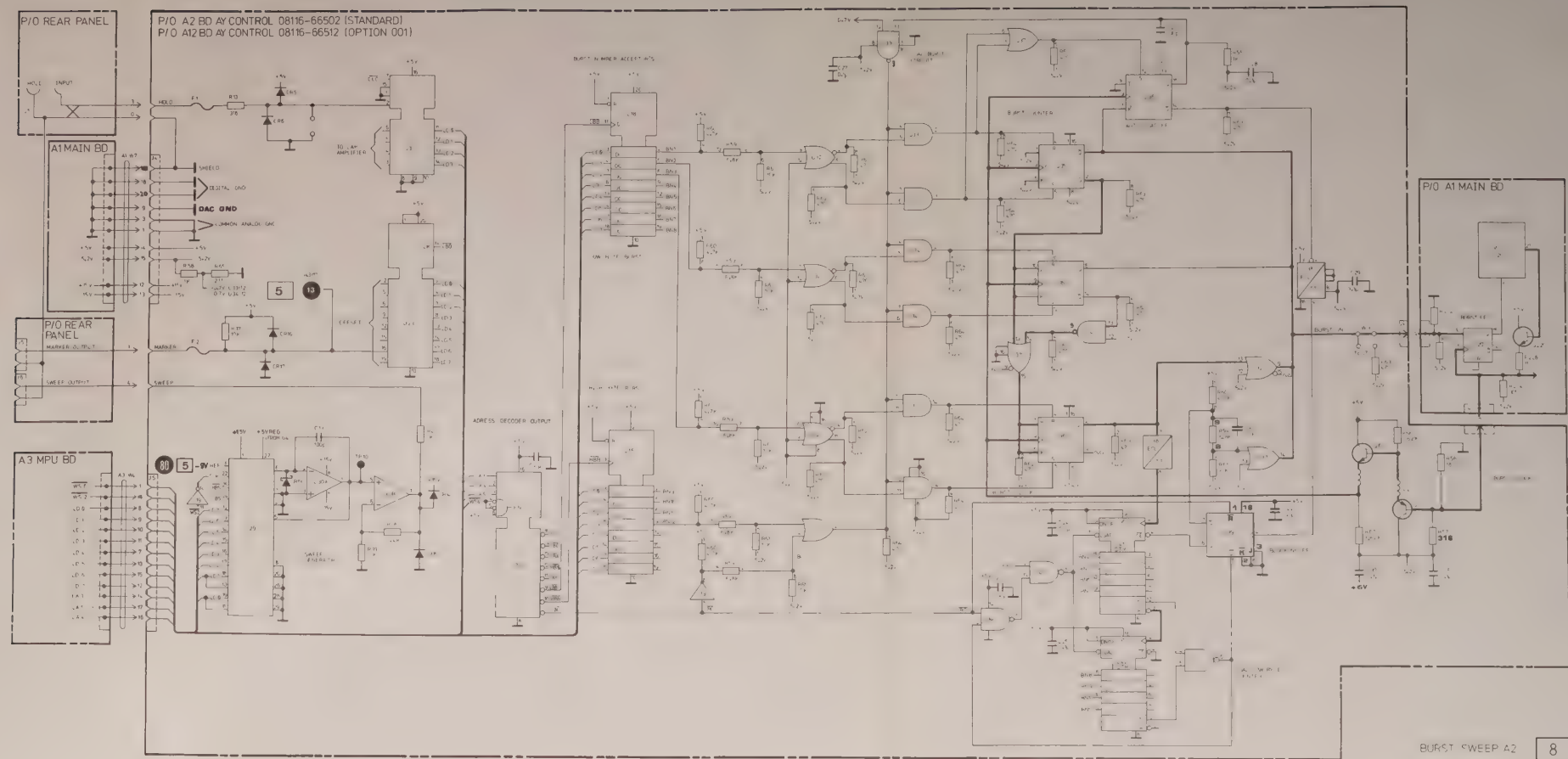
If the output in pulse or square wave has distorted leading or trailing edges, and the input signal at TP4 is undistorted, then make the following test:

Set the 8116A to high output amplitude.
If the leading edge is distorted, check Q503 and Q505.
If the trailing edge is distorted, check Q504 and Q506.

COMP	REF	COMP	REF
C260 F1	CR508 K1	R263 F4	
C261 F3	CR509 K1	R264 F2	
C262 F4	CR511 L1	R265 F2	
C263 F4	CR512 D1	R266 F3	
C264 F2	CR514 O2	R267 F2	
C400 K6	CR514 O2	R268 F2	
C401 L6	J3	R269 F3	
C402 L6	K501 M6	R270 F3	
C403 L5	K502 M7	R271 F3	
C404 L6	K503 M7	R272 F3	
C405 K7	K504 M6	R400 M8	
C406 L5	K505 O1	R401 M8	
C501 N8	L260 F3	R402 L7	
C502 M6	L261 F3	R403 M8	
C503 O7	L500 N4	R404 K6	
C504 N7	L501 N4	R405 K6	
C505 N7	L502 N3	R406 K6	
C506 N8	L503 N3	R407 K7	
C507 M5	L504 M3	R408 K6	
C508 O5	L505 O3	R409 K5	
C509 M6	L506 M3	R410 K7	
C510 O6	L509 M2	R411 K9	
C511 N5	L510 O3	R412 K6	
C512 N5	L511 O3	R413 K7	
C513 N5	Q260 F4	R414 K7	
C514 M4	Q261 F4	R415 L6	
C515 O4	Q262 F3	R416 L7	
C516 N4	Q263 F3	R417 L7	
C517 M3	Q401 L5	R418 L5	
C518 N3	Q402 L6	R419 L5	
C519 M3	Q403 L5	R420 L5	
C520 N2	Q430 L4	R421 M5	
C521 M2	Q431 L4	R422 K8	
C522 N2	Q432 L4	R423 L6	
C523 M1	Q433 L4	R424 L6	
C524 O2	Q501 M5	R425 M7	
C525 M3	Q502 O5	R426 L7	
C526 O1	Q503 M4	R427 L7	
C527 N2	Q504 O4	R428 L5	
C528 N4	Q505 M4	R430 L4	
C529 N4	Q506 O4	R431 L4	
C530 N4	Q507 N4	R432 L4	
C531 N4	Q508 N3	R433 L4	
C532 M6	Q509 N3	R434 L4	
C533 M6	Q510 M3	R435 L4	
C534 M6	Q511 O3	R436 L4	
C535 M6	Q512 M3	R437 M7	
C536 N7	Q513 O3	R438 K3	
C537 M6	Q514 N7	R439 L6	
C538 N3	Q515 N7	R440 L5	
C539 M5	Q590 L2	R441 L5	
C541 N3	Q591 L2	R442 L5	
C550 N8	R124 L6	R443 L5	
CR501 N8	R124 L6	R444 L5	
CR502 N6	R150 K3	R445 L5	
CR503 M6	R158 L2	R446 L5	
CR504 O6	R260 F4	R447 L5	
CR505 N3	R261 F4	R448 L5	
CR506 N3	R262 F4	R449 L5	
CR507 L2		R450 L5	



THIS SERVICE BLOCK APPLIES TO
OPTION 001
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SERVICE BLOCK 8 TROUBLESHOOTING GUIDE

NOTE: If an error code is shown in the display it is necessary to press a key, e.g. LCL, to set the u-Processor to normal routine, then troubleshoot the instrument.

The Output Address Decoder, which provides the logic control signals for Sweep Generator DAC, Burst Number Acceptors and Burst Counter on A2 Control Board Assy can be checked with Signature Analysis against table 8-8-2. Set the u-Processor to free run mode by setting the jumper P1 to "P1" position on board A3. Disconnect jumper A2W2 connect RES (A3) to gnd for a short time to reset the u-Processor.

Signature Analyzer	A3 u-Processor Board Assy
Start	TP "SA"
Stop	TP "SP"
Clock	TP "E"

Table 8-8-1. Signature Analyzer setting and connection to A3 u-Processor Board Assy

NOTE: Verify that reading at +5 V is 0003. If not, the u-Processor does not run free.

Burst Counter

The correct operation of the Burst Counter can be verified with the following test procedure, refer to figure 8-8-3 for the waveform and timing data.

1. Turn instrument off.
2. Desolder wire W3 on A2 Control Board and solder it to "test" position.
3. Connect A1 U203 pin 10 to ground.
4. Turn instrument on.
5. Set 8116A:

MODE E.BUR
FREQ 1.00 MHz
BUR 1024 #

6. Press MAN-Pushbutton.

Check logic TTL levels at Burst Number Acceptors U18 and U15.

BN1 thru BN 10	L
BN11	H

Table 8-8-3. U15 & U18 output for Burst Number 1024.

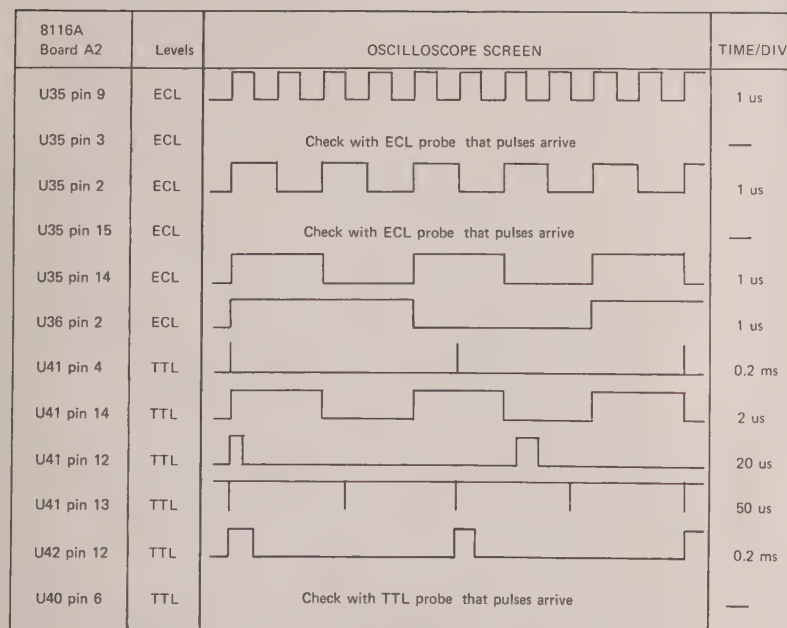
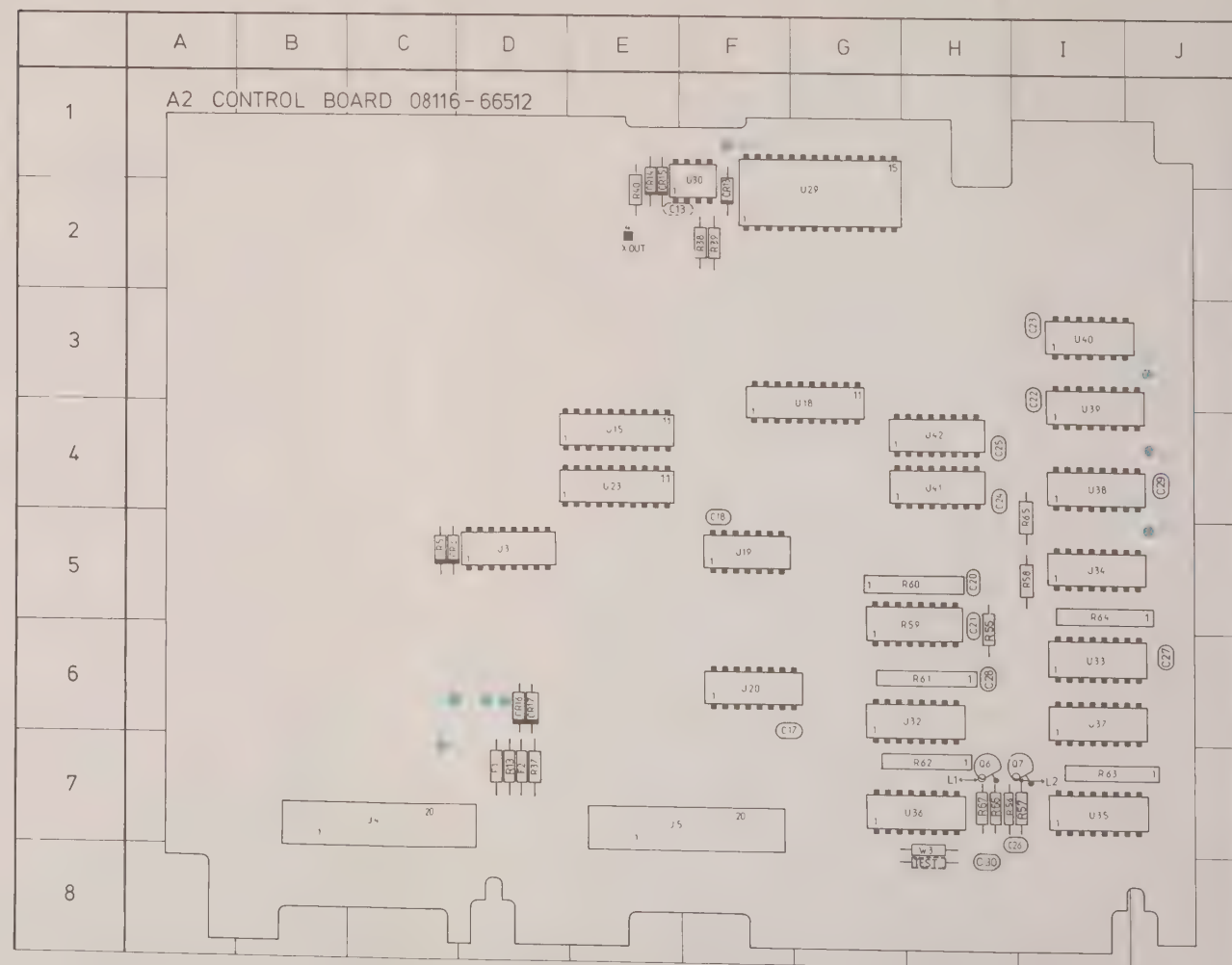


Figure 8-8-3. Burst Counter waveform and timing data

COMP	REF	COMP	REF
C13	E2	R56	H7
C17	F6	R57	H7
C20	H5	R58	H5
C21	H5	R59	H5
C22	I3	R60	H5
C23	I3	R61	H6
C24	H4	R62	H7
C25	H4	R63	I7
C26	H7	R64	I5
C27	J6	R65	I4
C28	H6	R66	H7
C29	J4	R67	H7
C30	H8	U3	B5
CR5	C5	U15	E4
CR6	C5	U18	E3
CR13	F2	U19	F5
CR14	E2	U20	F6
CR15	E2	U23	E4
CR16	D6	U29	G2
CR17	D6	U30	F1
F1	D7	U32	H6
F2	D7	U33	I6
J4	C7	U34	I5
J5	F7	U35	I7
L1	H7	U36	H7
L2	H7	U37	I6
Q6	H7	U38	I4
Q7	H7	U39	I3
R38	F2	U40	I3
R39	F2	U41	H4
R40	E1	U42	H4
R55	H5	W3	H7



Mnemonic	Description	"Free Run" Signatures see table 8-8-1
LA3 LA4 LA5 WS6	subdecoded Addresses	000000 000001 000010 000011
LBS	Low Byte Sweep	000000
HBS	High Byte Sweep	000001
LBB	Low Byte Burst	000010
HBB	High Byte Burst	000011
LBC	Load Burst Counter	000100

Table 8-8-2. Logic Control Signals-Mnemonics, Description & Signatures

BURST AND SWEEP THEORY OF OPERATION

Blocking Flip-Flop

The Blocking Flip-Flop serves a dual-purpose in this configuration. When counters U41 and U42 have cleared, the IC signals are gated by NAND gate U40B, so producing a low signal which sets the flip-flop. The Q output therefore switches high, disabling U41. $\bar{Q}$ output will now be low – the signal being gated to the wired-OR configuration (U32 U37). In the wired OR configuration, a logic high prevails, so in order for a logic low to be maintained (allowing the VCO to be disabled), all signals which come together here have to be low.

For the counter to be re-enabled, logic signal $\overline{\text{LBC}}$ must be set true (low) and gated with U40B signal. When $\overline{\text{LBC}}$ goes low, the Blocking Flip-Flop Q and $\overline{\text{Q}}$ outputs change state. Thus the $\overline{\text{CE}}$ signal is set true, enabling the counters and the wired-OR configuration output is high allowing the VCO to output the clock pulses once more.

The burst number is latched through the acceptors on receipt of **LBB** (low byte burst) and **HBB** (high byte burst) signals from the Address Decoder. The burst counter is then preset to the burst when **LBC** is received. The burst clock then initiates a count-down sequence which ends when the counter reaches "1".

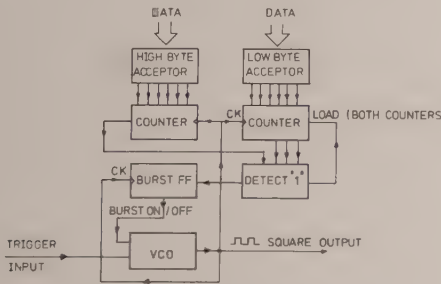


Figure 8-8-1. Simplified Burst generator

Hold Input

The principle of operation of this circuit depends upon a Digital to Analog conversion. DAC U29 performs a conversion of data from the latched bus and decoded data from the MPU board. The d.c. signal amplitude of the X-output represents 1.5 V for each frequency decade which has been swept, up to a maximum of 10 V (0 V corresponding to the start frequency).

Figure 8-8-2 shows the relationship between X-output amplitude and swept frequency decades.

The Marker Output is pre-programmed at the instrument frontpanel before the sweep has begun. The signal comes directly from the latched data bus via the offset latch and is converted from ECL to TTL in order to be compatible with any external instruments.

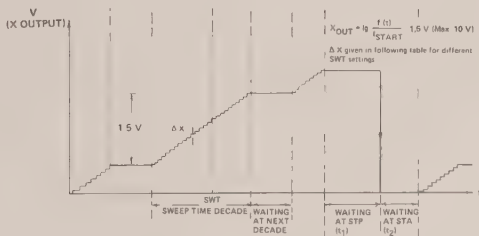


Figure 8-8-2. X output vs swept frequency



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CS Computer Systems Software Sales and Services
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M Medical Products
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 3939 Lankershim Blvd.
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 R. Barbosa Rodrigues, 41-I DT.
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Computer Maintenance Corp.

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BOMBAY 400 025
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T.C. 7/603 Poornima
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Arranged alphabetically by country

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M

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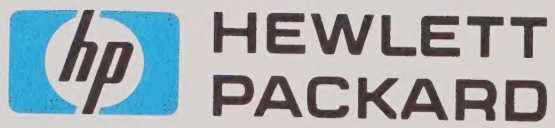
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